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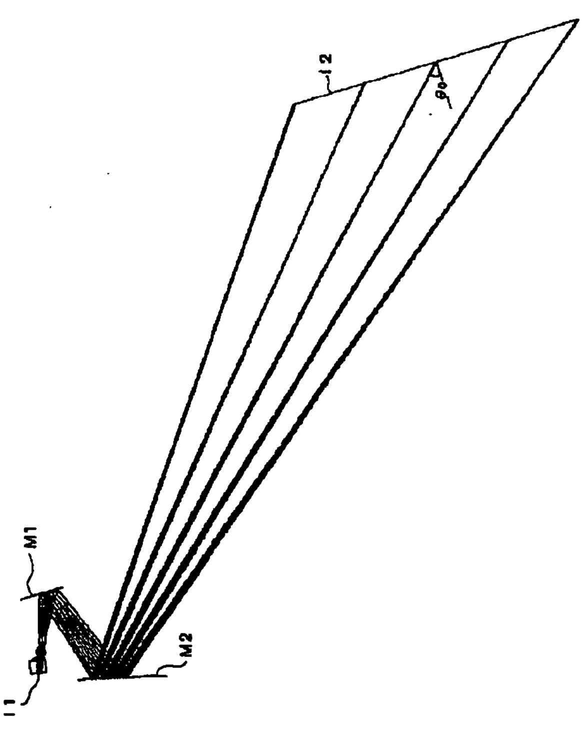
(54)【発明の名称】　斜め投影光学系

(57)【要約】
【課題】　斜め投影角度を十分にとりながらコンパクト化を達成した、製造容易で高性能な斜め投影光学系を提供する。
【解決手段】　１次像面(I1)から２次像面(I2)へ斜め方向に拡大投影する。互いに偏心した２つ以上の屈折レンズ群とパワーを有する１面以上の反射面を備える。像面(I1)中心から絞り(ST)中心を通り像面(I2)中心に到達する光線を画面中心光線とするとき、$10° < \theta o < 70°$，$0.40 < S1/S < 0.9$〔θo：画面中心光線が像面(I2)の法線となす角度、S：像面(I1)から像面(I2)までの画面中心光線の光路長、S1：像面(I2)から最初のパワーを有する光学面までの画面中心光線の光路長〕を満たす。



【特許請求の範囲】

【請求項１】　縮小側の１次像面から拡大側の２次像面への斜め方向の拡大投影を行う斜め投影光学系であって、互いに偏心した２つ以上の屈折レンズ群を備えるとともに、パワーを有する反射面を１面以上備え、前記１次像面から前記２次像面までに中間実像を結像することなく、前記１次像面の画面中心から絞りの中心を通り前記２次像面の画面中心に到達する光線を画面中心光線とするとき、以下の条件式を満たすことを特徴とする斜め投影光学系；

$10° < \theta o < 70°$

$0.40 < S1/S < 0.9$

ただし、

θo：画面中心光線が２次像面の法線となす角度、

S ：１次像面から２次像面までの画面中心光線の光路長、

S1：２次像面から最初のパワーを有する光学面までの画面中心光線の光路長

、である。

【請求項２】　前記１次像面と前記絞りとの間に屈折面のみが配置されていることを特徴とする請求項１記載の斜め投影光学系。

【請求項３】　前記反射面の１面以上が自由曲面形状を有することを特徴とする請求項１記載の斜め投影光学系。

【請求項４】　前記絞りより２次像面側に、前記反射面を構成する反射ミラーが２面配置されており、絞り側の反射ミラーが正パワーを有し、２次像面側の反射ミラーが負パワーを有することを特徴とする請求項１記載の斜め投影光学系。

【請求項５】　前記屈折レンズ群を構成している屈折レンズのうち最も１次像面側に配置されている屈折レンズが正のパワーを有し、以下の条件式を満たすことを特徴とする請求項１記載の斜め投影光学系；

$-1.7 < fs \times \beta y/S < -0.8$

ただし、fs：最も１次像面側の正の屈折レンズの焦点距離、

βy：斜め投影方向の拡大倍率、

である。

【請求項６】　一部の光学要素を動かすことでフォーカスを行うことを特徴とする請求項１記載の斜め投影光学系。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は斜め投影光学系に関するものであり、例えば１次像面から２次像面への斜め方向の拡大投影を行う、画像投影装置に好適な斜め投影光学系に関するものである。

【０００２】

【従来の技術】液晶ディスプレイ（ＬＣＤ：liquid crystal display)等に表示された画像をスクリーンに拡大投影する画像投影装置において、スクリーンの大型化を達成しつつも投影装置全体をコンパクトにする目的で、画像を斜め方向からスクリーンに拡大投影する装置が種々提案されている。その具体的な例としては、投影光学系のすべての光学要素を反射ミラーで構成した装置(特開平１０－１１１４７４号公報)、投影光学系のすべての光学要素を屈折レンズで構成した装置(特開平１０－２８２４５１号公報)、反射ミラーと屈折レンズとが組み合わされた投影光学系を有する装置(特開平９－１７９０６４号公報)が挙げられる。

【０００３】

【発明が解決しようとする課題】特開平１０－１１１４７４号公報で提案されているように、すべての光学要素を反射ミラーで構成すると、構成要素を少なくすることができる。しかし、反射ミラーには色収差補正の自由度がないため、多板式によるカラー化の構成では色合成用光学素子の配置に制約が生じてしまう。また、大径の曲面ミラーを低コストで得るためにはミラーをプラスチックで成型する必要があるが、プラスチック面上に高効率な反射コートを形成することは困難である。このため、プラスチック製のミラーを高輝度のプロジェクターに使用すると、ミラーの温度が上昇して反射面形状が変形し、収差の悪化や耐久性の低下を招くことになる。

【０００４】特開平１０－２８２４５１号公報で提案されているように、すべての光学要素を屈折レンズで構成すると、比較的小さい面積の光学要素で斜め投影を達成することができる。しかし、偏心したレンズ群が多数必要であり、そのうちのいくつかは大きく偏心させる必要があるため、光学要素の保持が困難である。特開平９－１７９０６４号公報で提案されているように、反射ミラーと屈折レンズとを組み合わせれば、偏心したレンズ群は少なくて済み、投影光学系の構成も簡単になる。しかし、パワーを有するとともに面積の非常に大きい製造困難なミラーが必要になる。

【０００５】本発明はこのような状況に鑑みてなされたものであって、斜め投影角度を十分にとりながらコンパクト化を達成した、製造容易で高性能な斜め投影光学系を提供することを目的とする。

【０００６】

【課題を解決するための手段】上記目的を達成するために、第１の発明の斜め投影光学系は、縮小側の１次像面から拡大側の２次像面への斜め方向の拡大投影を行う斜め投影光学系であって、互いに偏心した２つ以上の屈折レンズ群を備えるとともに、パワーを有する反射面を１面以上備え、前記１次像面から前記２次像面までに中間実像を結像することなく、前記１次像面の画面中心から絞りの中心を通り前記２次像面の画面中心に到達する光線を画面中心光線とするとき、以下の条件式を満たすことを特徴とする。

$10° < \theta o < 70°$
$0.40 < S1/S < 0.9$
ただし、
θo：画面中心光線が２次像面の法線となす角度、
S ：１次像面から２次像面までの画面中心光線の光路長、
S1：２次像面から最初のパワーを有する光学面までの画面中心光線の光路長
、である。
【０００７】第２の発明の斜め投影光学系は、上記第１の発明の構成において、前記１次像面と前記絞りとの間に屈折面のみが配置されていることを特徴とする。
【０００８】第３の発明の斜め投影光学系は、上記第１の発明の構成において、前記反射面の１面以上が自由曲面形状を有することを特徴とする。
【０００９】第４の発明の斜め投影光学系は、上記第１の発明の構成において、前記絞りより２次像面側に、前記反射面を構成する反射ミラーが２面配置されており、絞り側の反射ミラーが正パワーを有し、２次像面側の反射ミラーが負パワーを有することを特徴とする。
【００１０】第５の発明の斜め投影光学系は、上記第１の発明の構成において、前記屈折レンズ群を構成している屈折レンズのうち最も１次像面側に配置されている屈折レンズが正のパワーを有し、以下の条件式を満たすことを特徴とする。
$-1.7 < fs \times \beta y / S < -0.8$
ただし、
fs：最も１次像面側の正の屈折レンズの焦点距離、
βy：斜め投影方向の拡大倍率、
である。
【００１１】第６の発明の斜め投影光学系は、上記第１の発明の構成において、一部の光学要素を動かすことでフォーカスを行うことを特徴とする。
【００１２】
【発明の実施の形態】以下、本発明を実施した斜め投影光学系を、図面を参照しつつ説明する。図１に第１の実施の形態の１次像面(I1)から２次像面(I2)までの投影光路全体を示し、図２に第１の実施の形態の光学構成及び投影光路要部を示す。図５に第２の実施の形態の１次像面(I1)から２次像面(I2)までの投影光路全体を示し、図６に第２の実施の形態の光学構成及び投影光路要部を示す。また、図９及び図１０に第３の実施の形態の１次像面(I1)から２次像面(I2)までの投影光路全体を各フォーカスポジション(i),(ii)について示し、図１１及び図１２に第３の実施の形態の光学構成及び投影光路要部を各フォーカスポジション(i),(ii)について示す。なお、これらの光路図は後述の直交座標系(X,Y,Z)におけるY-Z断面構成を示しており、図２，図６，図１１及び図１２中、*印が付された面は非球面、$印が付された面は自由曲面であることを示している。
【００１３】各実施の形態は、縮小側の１次像面(I1)から拡大側の２次像面(I2)への斜め方向の拡大投影を行う、画像投影装置用の斜め投影光学系である。したがって、１次像面(I1)は２次元画像を表示する表示素子(例えばＬＣＤ)の表示面に相当し、２次像面(I2)は投影像面(つまりスクリーン面)に相当する。なお、２次像面(I2)から１次像面(I1)への斜め方向の縮小投影を行う斜め投影光学系として、各実施の形態を画像読み取り装置に用いることも可能である。その場合、１次像面(I1)は画像読み取りを行う受光素子〔例えばＣＣＤ(Charge Coupled Device)〕の受光面に相当し、２次像面(I2)は読み取り画像面(つまりフィルム等の原稿面)に相当する。
【００１４】第１の実施の形態(図１，図２)は、１次像面(I1)側(縮小側)から順に、プリズムブロック(Pr)と、偏心した１枚の屈折レンズから成る第１屈折レンズ群(G1)と、共軸系を成す４枚の屈折レンズから成る第２屈折レンズ群(G2)と、絞り(ST)と、正パワーを有する第１反射ミラー(M1)と、負パワーを有する第２反射ミラー(M2)と、で構成されている。第１屈折レンズ群(G1)を構成している屈折レンズの縮小側面は非球面から成っており、第１，第２反射ミラー(M1,M2)の反射面は自由曲面から成っている。
【００１５】第２の実施の形態(図５，図６)は、１次像面(I1)側(縮小側)から順に、プリズムブロック(Pr)と、偏心した１枚の屈折レンズから成る第１屈折レンズ群(G1)と、共軸系を成す４枚の屈折レンズから成る第２屈折レンズ群(G2)と、絞り(ST)と、偏心した１枚の屈折レンズから成る第３屈折レンズ群(G3)と、偏心した１枚の屈折レンズから成る第４屈折レンズ群(G4)と、負パワーを有する第１反射ミラー(M1)と、で構成されている。第１屈折レンズ群(G1)を構成している屈折レンズの縮小側面は非球面から成っており、第４屈折レンズ群(G4)を構成している屈折レンズの拡大側面は自由曲面から成っており、第１反射ミラー(M1)の反射面は自由曲面から成っている。
【００１６】第３の実施の形態(図９〜図１２)は、１次像面(I1)側(縮小側)から順に、プリズムブロック(Pr)と、偏心した１枚の屈折レンズから成る第１屈折レンズ群(G1)と、共軸系を成す４枚の屈折レンズから成る第２屈折レンズ群(G2)と、絞り(ST)と、正パワーを有する第１反射ミラー(M1)と、負パワーを有する第２反射ミラー(M2)と、で構成されている。第１屈折レンズ群(G1)を構成している屈折レンズの縮小側面は非球面、拡大側面は自由曲面から成っており、第１，第２反射ミラー(M1,M2)の反射面は自由曲面から成っている。第３の実施の形態のフォーカスは、第２屈折レンズ群(G2)が平行移動することにより行われる。例えば、図９，図１１に示すフォーカスポジション(i)において、第２屈折レンズ群(G2)を矢印ｍＦ方向(図１１)に移動させると、図１０，図１２に示すフォーカスポジション(ii)となる。なお、フ

ォーカス時には絞り(ST)が第２屈折レンズ群(G2)と共に移動する。

【００１７】各実施の形態のように、互いに偏心した２つ以上の屈折レンズ群(G1,G2,…)を備えるとともに、パワーを有する反射面(M1,…)を１面以上備え、また１次像面(I1)から２次像面(I2)までに中間実像を結像することのない構成とするのが望ましい。これにより、高い光学性能を保持しながら、斜め投影光学系を薄型のコンパクトにすることが可能となる。プロジェクターに用いられるカラー化のための多板構成では、クロスダイクロイックプリズム等のガラスブロックが一般に必要とされるが、ガラスブロックの入射面や射出面に対して斜めに投影光が通過すると色収差が発生してしまう。上記のように屈折レンズ群(G1,G2,…)を備えていれば、色収差の補正が可能である。また、反射型表示素子(例えば反射型ＬＣＤ)を斜め方向から照明することが可能になるため、偏光ビームスプリッター(ＰＢＳ)等を用いる必要がなくなり低コスト化を達成することができる。

【００１８】１次像面(I1)の画面中心から絞り(ST)の中心を通り２次像面(I2)の画面中心に到達する光線を「画面中心光線」とするとき、１次像面(I1)と２次像面(I2)との間での中間実像の結像なしに、以下の条件式(1)及び(2)を満たすことが望ましい。

$10° < \theta o < 70°$ …(1)

$0.40 < S1/S < 0.9$ …(2)

ただし、

θo：画面中心光線が２次像面(I2)の法線となす角度、

S ：１次像面(I1)から２次像面(I2)までの画面中心光線の光路長、

S1：２次像面(I2)から最初のパワーを有する光学面までの画面中心光線の光路長、である。

【００１９】条件式(1)の上限を超えると、斜め投影による台形歪みを補正することが困難になる。条件式(1)の下限を超えると、斜め投影による薄型化の効果が小さくなってしまう。条件式(2)の上限を超えると、投影距離が長くなりすぎて薄型化の効果が小さくなる。条件式(2)の下限を超えると、拡大側の２次像面(I2)に近い光学素子の径が過大となり、コストアップとともにその製造が困難になる。

【００２０】さらに以下の条件式(3)を満たすことが望ましい。

$40° < \theta o < 60°$ …(3)

【００２１】条件式(3)は、角度θoの更に好ましい条件範囲を規定している。条件式(3)の上限を超えると、台形歪み及び像面湾曲を補正するために自由曲面が多く必要になり、その分コストが高くなる。さらに、投影スクリーンに対する入射角度が大きくなるため、スクリーンにおいて観察者の方向に大きく光を曲げる必要が生じる。したがって、スクリーンの構造が複雑になりコストが高くなる。条件式(3)の下限を超えると、斜め投影による効果的な薄型化が難しくなる。

【００２２】各実施の形態のように、反射面の１面以上が自由曲面形状を有することが望ましい。自由曲面形状とは、大きく偏心した非球面を含むとともに回転対称軸を有効領域内に持たないような回転非対称な面形状である(各実施の形態に用いられている反射面は、Y-Z平面に対して対称な自由曲面形状を有する。)。斜め投影では非軸対称な収差補正が必要となるが、自由曲面形状を有する反射面を１面以上用いることにより、少ない光学要素で斜め投影による非軸対称な収差補正が可能となる。また、２面以上の自由曲面を用いることが更に望ましい。自由曲面形状を有する反射面を２面以上用いることにより、斜め投影の台形歪みを主に補正する自由曲面〔２次像面(I2)に近接した自由曲面〕と、斜め投影による非対称な像面湾曲及び非点隔差を補正する自由曲面〔絞り(ST)に近接した自由曲面〕と、に収差補正が分担可能になるため、より高性能な投影光学系を達成することができる。

【００２３】ところで、投影光学系を反射ミラーのみで構成する場合には、できるだけ多くのミラー面を自由曲面形状にする必要がある。自由曲面や非球面は、一般にプラスチックで形成することがコスト的に有利であるが、プラスチック面上に多層の誘電体多層膜を形成することは困難である。このため、プラスチックで構成された自由曲面ミラーでは、その反射率が可視域での平均で９５％以下となる。残りの数％の光はプラスチック面に吸収されて熱になるため、反射ミラーの温度は上昇してしまう。プラスチック製の反射ミラーは耐熱性が低いため、温度上昇によって反射面形状が変形し、それが収差の悪化や耐久性の低下を招くことになる。

【００２４】特に１次像面(I1)近傍から絞り(ST)近傍にかけての領域では、光が集中することになるため、上記熱の問題は重大であり、その領域にプラスチック製の自由曲面ミラーを配置することは不可能である。この問題を解決するには、１次像面(I1)近傍から絞り(ST)近傍にかけての領域に、非球面又は自由曲面を有するプラスチックレンズ，ガラスレンズ等の屈折系の光学素子を配置することが望ましい。屈折系の光学素子であれば、その透過率が１面で９９％程度に抑えられるため、自由曲面をプラスチックで構成しても上記熱の問題を回避することができる。また１次像面(I1)近傍から絞り(ST)近傍にかけての領域に、ガラス成型により得られる自由曲面ミラーを配置してもよい。ガラスはプラスチックよりも耐熱性が高いため、上記熱の問題を回避することが可能である。

【００２５】各実施の形態のように、１次像面(I1)と絞り(ST)との間に屈折面のみが配置された構成では、上述した観点から上記熱の問題を回避することができる。屈折面は反射面よりも耐熱性に優れるため、１次像面(I1)と絞り(ST)との間に屈折面を構成する屈折系の光学素子

(非球面又は自由曲面を有するプラスチックレンズやガラスレンズ)を用いれば、上記熱の問題を回避しつつより明るい照明を行うことが可能となる。また、1次像面(I1)と絞り(ST)との間は空間的に余裕のない領域であるが、この領域で反射ミラーによる光線の折り返しをしないことにより、1次像面(I1)を照明する照明光学系の配置が容易になるという効果もある。

【0026】第1，第3の実施の形態のように、絞り(ST)より2次像面(I2)側に反射ミラー(M1,M2)が2面配置された構成において、絞り(ST)側の第1反射ミラー(M1)が正パワーを有し、2次像面(I2)側の第2反射ミラー(M2)が負パワーを有することが望ましい。絞り(ST)に近い第1反射ミラー(M1)のパワーを正にすることで、第1反射ミラー(M1)から第2反射ミラー(M2)への光束を収束ぎみにすることができる。したがって、第2反射ミラー(M2)を小さくすることができるため、コスト面や製造しやすさの面で有利になる。さらに、第2反射ミラー(M2)のパワーを負にすることで、短い投影距離でも大きな画面の投影が可能になるため、投影光学系全体をコンパクトにすることができる。

【0027】各実施の形態のように、屈折レンズ群(G1, …)を構成している屈折レンズのうち最も1次像面(I1)側に配置されている屈折レンズ(G1)が正のパワーを有し、以下の条件式(4)を満たすことが望ましい。

$-1.7 < fs \times \beta y / S < -0.8$ …(4)

ただし、

fs：最も1次像面(I1)側の正の屈折レンズ(G1)の焦点距離、

βy：斜め投影方向の拡大倍率、

である。

【0028】条件式(4)の下限を超えると、表示素子からの光がテレセントリックから大きく外れるため、色合成プリズムで発生する色ムラが許容できなくなるとともに、投影光学系の全長が大きくなりすぎてしまう。条件式(4)の上限を超えると、このレンズのパワーが強くなりすぎるために発生する像面湾曲と歪曲が過大となり、補正が困難になる。

【0029】フォーカスに関しては、第3の実施の形態のように一部の光学要素を動かすことで行うのが望ましい。表示素子移動によるフォーカスは、多板方式においてフォーカスに伴う画素ズレを生じさせやすい。したがって、フォーカスと画素ズレ調整を同時に行う必要が生じるため、作業時間が長くなるという問題がある。また、光学系全体を動かすフォーカスは、移動部材が大きいためフォーカス機構自体も大きくなり、コストが高くなる。したがって、一部の光学要素(屈折系の光学素子，反射系の光学素子)を動かすことでフォーカスを行う構成が望ましい。この構成によると、多板構成における画素ズレ調整のための表示素子移動とフォーカスとが独立するため、フォーカス及び画素ズレ調整作業が簡単になり、フォーカス機構自体もコンパクト化が達成される。第3の実施の形態のように一部の光学要素を平行に動かすこと(すなわち平行移動)でフォーカスを行うことが更に望ましい。これにより、フォーカスの移動機構がより簡単になり、コストを安くすることができる。

【0030】

【実施例】以下、本発明を実施した斜め投影光学系の構成を、コンストラクションデータ，スポットダイアグラム等を挙げて、更に具体的に説明する。ここで例として挙げる実施例1～3は、前述した第1～第3の実施の形態にそれぞれ対応しており、各実施の形態を表す図(図1，図2；図5，図6；図9～図12)は、対応する各実施例の光路等をそれぞれ示している。

【0031】各実施例のコンストラクションデータにおいて、si(i=1,2,3,...)は、縮小側の1次像面(I1；拡大投影における物面に相当する。)及び拡大側の2次像面(I2；拡大投影における像面に相当する。)を含めた系において、縮小側から数えてi番目の面であり、ri(i=1,2,3,...)は面siの曲率半径(mm)である。また、di(i=1,2,3,...)は、縮小側から数えてi番目の軸上面間隔(mm，偏心面間隔は偏心データとして記載。)を示しており、Ni(i=1,2,3,...)，νi(i=1,2,3,...)は縮小側から数えてi番目の光学素子のd線に対する屈折率(Nd)，アッベ数(νd)をそれぞれ示している。なお、各フィールドポジションに対応する1次像面(I1)側の物高(mm)を併せて示し、また、表1に各実施例の条件式対応値及び関連データを示す。

【0032】*印が付された面siは軸対称な非球面であり、その面形状は面頂点を原点とする直交座標系(x,y,z)を用いた以下の式(AS1)で定義される。また、$印が付された面siは自由曲面であり、その面形状は面頂点を原点とする直交座標系(x,y,z)を用いた以下の式(AS2)で定義される。非球面データ及び自由曲面データを他のデータと併せて示す。

【0033】

$$z=(c\cdot h^2)/[1+\sqrt{[1-c^2\cdot h^2]}]+(A\cdot h^4+B\cdot h^6+C\cdot h^8+D\cdot h^{10}) \quad \cdots(AS1)$$

【数1】

$$z=(c\cdot h^2)/[1+\sqrt{\{1-(1+K)\cdot c^2\cdot h^2\}}]+\sum_m \sum_n [C(m,n)\cdot x^m\cdot y^n] \quad \cdots(AS2)$$

【0034】ただし、

z：高さhの位置での光軸方向の基準面からの変位量、

h：光軸に対して垂直な方向の高さ($h^2=x^2+y^2$)、

c：近軸曲率(=1／曲率半径)、

A,B,C,D：非球面係数、

K：コーニック定数、

C(m,n)：自由曲面係数、
である。

【0035】縮小側直前に位置する面に対して偏心した面については、偏心データを直交座標系(X,Y,Z)に基づいて示す。直交座標系(X,Y,Z)においては、1次像面(s1)の中心位置を原点(0,0,0)とする面頂点座標(XDE,YDE,ZDE)=〔X軸方向の平行偏心位置(mm)，Y軸方向の平行偏心位置(mm)，Z軸方向の平行偏心位置(mm)〕で、平行偏心した面の位置を表すとともに、その面の面頂点を中心とするX軸回りの回転角ADE(°)で、回転偏心位置(光路図中、紙面に向かって反時計回りを正とする。)を表す。光路図中、X軸方向は紙面に対して垂直方向であり(紙面の裏面方向を正とする。)、Y軸方向は1次像面(s1)と紙面とが交わる直線方向であり(光路図の上方向を正とする。)、Z軸方向は1次像面(s1)の法線方向である〔2次像面(I2)側を正とする。〕。なお、実施例3についてはフォーカスにより変化する面頂点座標(YDE,ZDE)を併せて示す。

【0036】各実施例の光学性能をスポットダイアグラム(図3；図7；図13，図14)と歪曲図(図4；図8；図15，図16)でそれぞれ示す。スポットダイアグラムは2次像面(I2)での結像特性(mm)をd線，g線及びc線の3波長について示しており、歪曲図は1次像面(I1)での長方形状網目に対応する2次像面(I2)での光線位置(mm)を示している。歪曲図中、D1(実線)が実施例の歪曲格子であり、D0(点線)がアナモ比を考慮した理想像点の格子(歪曲無し)である。なお、X軸と同方向にx軸をとり、x軸に対して垂直で、かつ、1次像面(I1)に対して平行な方向にy軸をとった場合、物高は1次像面(I1)の画面中心を原点とする座標(x,y)で表される。また、X軸と同方向にx'軸をとり、x'軸に対して垂直で、かつ、2次像面(I2)に対して平行な方向にy'軸をとった場合、像高は2次像面(I2)の画面中心を原点とする座標(x',y')で表される。したがって、各歪曲図はx'-y'平面に対して垂直方向から見た2次像面(I2)上での実際の像の歪曲状態(ただしx'の負側のみ)を示していることになる。

【0037】

《実施例1》

〔面〕　〔曲率半径等〕〔軸上面間隔〕　〔屈折率〕　　〔アッベ数〕

〔1次像面(I1)〕

s1　r1= ∞

〔プリズムブロック(Pr)〕

s2　r2= ∞
XDE=0.000000,YDE=0.000000,ZDE=2.000000,ADE=8.231146
d2=25.000000　N1=1.516800　ν1=64.17

s3　r3= ∞

〔第1屈折レンズ群(G1)〕

s4*　r4=　46.70870
$A=-0.143476\times10^{-4}$, $B=0.336127\times10^{-7}$, $C=-0.100793\times10^{-9}$
$D=0.169578\times10^{-12}$
XDE=0.000000,YDE=-0.209423,ZDE=27.884859,ADE=2.863299
d4= 5.054112　N2=1.516800　ν2=64.17

s5　r5= -23.80876

〔第2屈折レンズ群(G2)〕

s6　r6=　17.16844
XDE=0.000000,YDE=-3.800929,ZDE=37.839776,ADE=-5.724528
d6= 8.214673　N3=1.754500　ν3=51.5700

s7　r7= -183.84669
d7= 0.437109

s8　r8= -36.61565
d8= 0.550000　N4=1.634801　ν4=31.1517

s9　r9=　11.51501
d9= 2.998133

s10　r10= -14.20564
d10=3.078071　N5=1.646976　ν5=30.1061

s11　r11= -36.35997
d11=7.611291

s12　r12= -97.19418

d12=1.254406　N6=1.754500　ν6=51.5700
s13　r13= -19.09051
d13=0.100000
〔絞り(ST)〕
s14　r14= ∞(絞り半径=5.528787)
〔第1反射ミラー(M1)〕
s15$　r15=-515.18948
XDE=0.000000, YDE=-3.880643, ZDE=162.698182, ADE=40.395892
K=0.000000
C(0,1)= 4.5091×10^{-1} ,C(2,0)=-3.9754×10^{-4} ,C(0,2)=-4.3444×10^{-4}
C(2,1)=-9.2883×10^{-6} ,C(0,3)=-8.9339×10^{-6} ,C(4,0)=-3.3775×10^{-8}
C(2,2)=-6.0399×10^{-8} ,C(0,4)= 3.4705×10^{-8} ,C(4,1)= 2.9641×10^{-9}
C(2,3)= 3.7180×10^{-9} ,C(0,5)= 2.9922×10^{-9} ,C(6,0)= 3.7758×10^{-11}
C(4,2)= 8.4198×10^{-11},C(2,4)= 1.0632×10^{-10},C(0,6)= 2.4061×10^{-11}
C(6,1)=-9.7584×10^{-13},C(4,3)= 1.2522×10^{-12},C(2,5)= 1.7911×10^{-12}
C(0,7)=-6.4844×10^{-13},C(8,0)=-1.6691×10^{-14},C(6,2)=-1.7447×10^{-15}
C(4,4)= 1.8389×10^{-14},C(2,6)= 1.7057×10^{-14},C(0,8)=-1.2407×10^{-14}
〔第2反射ミラー(M2)〕
s16$　r16=11790.68206
XDE=0.000000, YDE=-221.232416, ZDE=-1.216178, ADE=63.818350
K=0.000000
C(0,1)= 1.9367　,C(2,0)=-2.5631×10^{-3} ,C(0,2)=-7.1973×10^{-3}
C(2,1)= 9.2605×10^{-6} ,C(0,3)= 2.1326×10^{-4} ,C(4,0)= 8.9157×10^{-8}
C(2,2)=-2.1518×10^{-6} ,C(0,4)=-6.9456×10^{-7} ,C(4,1)=-4.4593×10^{-9}
C(2,3)= 5.9549×10^{-8} ,C(0,5)=-1.5015×10^{-7} ,C(6,0)=-4.7449×10^{-11}
C(4,2)= 2.8377×10^{-10},C(2,4)=-9.6994×10^{-10},C(0,6)= 4.0579×10^{-9}
C(6,1)=-4.8820×10^{-14},C(4,3)=-6.0060×10^{-12},C(2,5)= 8.4012×10^{-12}
C(0,7)=-4.5581×10^{-11},C(8,0)= 1.1592×10^{-14},C(6,2)= 3.5666×10^{-15}
C(4,4)= 4.7297×10^{-14},C(2,6)=-3.0020×10^{-14},C(0,8)= 1.9608×10^{-13}
〔2次像面(I2)〕
s17　r17= ∞
XDE=0.000000, YDE=-791.632950, ZDE=1233.624811, ADE=17.190021

【0038】
〔各ﾌｨｰﾙﾄﾞﾎﾟｼﾞｼｮﾝに対応する1次像面(I1)側の物高〕
(x,y)=(0.00000, 0.00000), (0.00000, 3.73600), (0.00000, 1.86800),
(0.00000,-1.86800), (0.00000,-3.73600), (3.32075, 3.73600),
(3.32075, 0.00000), (3.32075,-3.73600), (6.64150, 3.73600),
(6.64150, 1.86800), (6.64150, 0.00000), (6.64150,-1.86800),
(6.64150,-3.73600)

【0039】
《実施例2》
〔面〕　〔曲率半径等〕〔軸上面間隔〕〔屈折率〕　〔アッベ数〕
〔1次像面(I1)〕
s1　r1= ∞
d1= 0.100000
〔プリズムブロック(Pr)〕
s2　r2= ∞
d2=40.000000　N1=1.516800　ν1=64.17
s3　r3= ∞
〔第1屈折レンズ群(G1)〕

s4* r4= 37.22004
$A=-0.687561\times10^{-5}$, $B=0.305656\times10^{-8}$, $C=-0.432821\times10^{-11}$
$D=0.178300\times10^{-14}$
XDE=0.000000, YDE=1.230868, ZDE=41.092651, ADE=-11.272977
d4= 9.478934 N2=1.516800 ν2=64.17
s5 r5= -75.16721
〔第2屈折レンズ群(G2)〕
s6 r6= 18.43381
XDE=0.000000, YDE=-4.657780, ZDE=63.581617, ADE=-2.914203
d6= 6.957547 N3=1.753490 ν3=51.6038
s7 r7= -249.34663
d7= 0.100000
s8 r8= -223.20442
d8= 0.900000 N4=1.675123 ν4=28.2701
s9 r9= 12.75359
d9=12.989344
s10 r10= -14.76633
d10=9.137331 N5=1.847429 ν5=26.2798
s11 r11= -21.50143
d11=0.100000
s12 r12= 60.06702
d12=2.260898 N6=1.753409 ν6=51.6065
s13 r13= -66.17530
d13=0.100000
〔絞り(ST)〕
s14 r14= ∞(絞り半径=8.929177)
〔第3屈折レンズ群(G3)〕
s15 r15= 60.56155
XDE=0.000000, YDE=-5.308920, ZDE=107.168486, ADE=-12.460990
d15=5.040667 N7=1.801983 ν7=22.6887
s16 r16= 38.17795
〔第4屈折レンズ群(G4)〕
s17 r17= -82.51476
XDE=0.000000, YDE=-24.514254, ZDE=134.213398, ADE=11.867790
N8=1.600000 ν8=50.0000
s18$ r18= -48.20057
XDE=0.000000, YDE=-21.429443, ZDE=148.892769, ADE=17.627981
K=0.000000
$C(0,1)=-1.2629\times10^{-2}$, $C(2,0)= 7.6324\times10^{-3}$, $C(0,2)= 8.8274\times10^{-3}$
$C(2,1)=-9.0235\times10^{-5}$, $C(0,3)=-8.8068\times10^{-5}$, $C(4,0)= 3.0504\times10^{-6}$
$C(2,2)= 5.1991\times10^{-6}$, $C(0,4)= 1.3647\times10^{-6}$, $C(4,1)=-1.2274\times10^{-7}$
$C(2,3)= 9.1338\times10^{-8}$, $C(0,5)= 1.3392\times10^{-7}$, $C(6,0)= 1.5795\times10^{-9}$
$C(4,2)= 1.0046\times10^{-8}$, $C(2,4)=-8.3371\times10^{-9}$, $C(0,6)=-5.4608\times10^{-9}$
$C(6,1)=-1.8409\times10^{-10}$, $C(4,3)=-4.7482\times10^{-10}$, $C(2,5)= 2.1921\times10^{-10}$
$C(0,7)= 8.8471\times10^{-11}$, $C(8,0)= 2.0063\times10^{-12}$, $C(6,2)= 8.6883\times10^{-12}$
$C(4,4)= 1.0236\times10^{-11}$, $C(2,6)=-9.5143\times10^{-13}$, $C(0,8)=-2.4945\times10^{-13}$
〔第1反射ミラー(M1)〕
s19$ r19= 484.60696
XDE=0.000000, YDE=-32.721774, ZDE=338.544609, ADE=19.876412
K=0.000000

$C(0,1)=1.5307$, $C(2,0)=1.2746\times10^{-3}$, $C(0,2)=1.6045\times10^{-3}$
$C(2,1)=-2.7069\times10^{-5}$, $C(0,3)=-4.1320\times10^{-5}$, $C(4,0)=-9.8465\times10^{-8}$
$C(2,2)=-1.1160\times10^{-7}$, $C(0,4)=-1.8515\times10^{-7}$, $C(4,1)=2.5453\times10^{-9}$
$C(2,3)=7.3428\times10^{-9}$, $C(0,5)=9.5282\times10^{-9}$, $C(6,0)=6.2489\times10^{-12}$
$C(4,2)=-1.9710\times10^{-11}$, $C(2,4)=-7.0208\times10^{-11}$, $C(0,6)=3.8356\times10^{-12}$
$C(6,1)=-1.0859\times10^{-13}$, $C(4,3)=-2.6945\times10^{-13}$, $C(2,5)=-3.4077\times10^{-14}$
$C(0,7)=-2.0958\times10^{-12}$, $C(8,0)=-3.4342\times10^{-16}$, $C(6,2)=1.5410\times10^{-15}$
$C(4,4)=2.8319\times10^{-15}$, $C(2,6)=2.2998\times10^{-15}$, $C(0,8)=1.5687\times10^{-14}$

〔2次像面(I2)〕
s20 r20= ∞
XDE=0.000000, YDE=847.663047, ZDE=94.096282, ADE=-31.350316

【0040】
〔各ﾌｨｰﾙﾄﾞﾎﾟｼﾞｼｮﾝに対応する1次像面(I1)側の物高〕
(x, y)=(0.00000, 0.00000), (0.00000, 9.00000), (0.00000, 4.50000),
(0.00000, -4.50000), (0.00000, -9.00000), (6.00000, 9.00000),
(6.00000, 0.00000), (6.00000, -9.00000), (12.00000, 9.00000),
(12.00000, 4.50000), (12.00000, 0.00000), (12.00000, -4.50000),
(12.00000, -9.00000)

【0041】
《実施例3》
〔面〕 〔曲率半径等〕〔軸上面間隔〕 〔屈折率〕 〔アッベ数〕
〔1次像面(I1)〕
s1 r1= ∞
d1= 0.100000
〔プリズムブロック(Pr)〕
s2 r2= ∞
d2=40.000000 N1=1.516800 ν1=64.17
s3 r3= ∞
〔第1屈折レンズ群(G1)〕
s4* r4= 27.15757
$A=-0.159264\times10^{-4}$, $B=0.278084\times10^{-7}$, $C=-0.392459\times10^{-10}$
$D=0.165520\times10^{-13}$
XDE=0.000000, YDE=1.104200, ZDE=40.200000, ADE=1.828800
d4= 8.217708 N2=1.516800 ν2=64.17
s5$ r5= -59.69786
K=0.000000
$C(0,1)=-4.1697\times10^{-2}$, $C(2,0)=-1.0437\times10^{-3}$, $C(0,2)=-6.9849\times10^{-4}$
$C(2,1)=2.7171\times10^{-5}$, $C(0,3)=1.5774\times10^{-5}$, $C(4,0)=-2.1151\times10^{-7}$
$C(2,2)=-1.5052\times10^{-7}$, $C(0,4)=-7.8598\times10^{-7}$, $C(4,1)=-2.4605\times10^{-8}$
$C(2,3)=2.7285\times10^{-8}$, $C(0,5)=2.9623\times10^{-8}$, $C(6,0)=2.0889\times10^{-8}$
$C(4,2)=5.1467\times10^{-8}$, $C(2,4)=4.9394\times10^{-8}$, $C(0,6)=1.8655\times10^{-8}$
$C(6,1)=-3.4631\times10^{-11}$, $C(4,3)=-1.1603\times10^{-10}$, $C(2,5)=-4.0374\times10^{-10}$
$C(0,7)=-1.0193\times10^{-10}$, $C(8,0)=-2.7915\times10^{-11}$, $C(6,2)=-8.5645\times10^{-11}$
$C(4,4)=-1.0836\times10^{-10}$, $C(2,6)=-9.5474\times10^{-11}$, $C(0,8)=-2.0106\times10^{-11}$
〔第2屈折レンズ群(G2)〕
s6 r6= 46.72081
XDE=0.000000, YDE=0.343200, ZDE=54.793000, ADE=-0.046400
d6= 3.648127 N3=1.746892 ν3=51.8282
s7 r7= -106.07118
d7= 2.256696

s8 r8= -36.98381
d8=10.051440 N4=1.639391 ν4=30.7444
s9 r9= 18.55035
d9= 5.365573
s10 r10= -32.78870
d10=7.024369 N5=1.605973 ν5=34.1504
s11 r11= 43.56262
d11=0.145875
s12 r12= 42.32336
d12=11.083877 N6=1.764916 ν6=42.3487
s13 r13= -27.53907
d13=0.100000
〔絞り(ST)〕
s14 r14= ∞(絞り半径=8.518602)
〔第1反射ミラー(M1)〕
s15$ r15=-301.34410
XDE=0.000000, YDE=20.461272, ZDE=194.484643, ADE=39.903360
K=0.000000
$C(0,1)= 4.5423\times10^{-1}$, $C(2,0)= 4.5039\times10^{-4}$, $C(0,2)= 1.6186\times10^{-4}$
$C(2,1)=-9.0834\times10^{-6}$, $C(0,3)=-8.5756\times10^{-6}$, $C(4,0)=-2.4624\times10^{-8}$
$C(2,2)=-1.9352\times10^{-9}$, $C(0,4)= 6.7051\times10^{-8}$, $C(4,1)= 2.9051\times10^{-9}$
$C(2,3)= 6.2404\times10^{-9}$, $C(0,5)= 2.7989\times10^{-9}$, $C(6,0)= 2.7038\times10^{-11}$
$C(4,2)= 1.2518\times10^{-10}$, $C(2,4)= 2.3993\times10^{-10}$, $C(0,6)= 3.8914\times10^{-11}$
$C(6,1)= 5.0561\times10^{-13}$, $C(4,3)= 4.3033\times10^{-12}$, $C(2,5)= 5.4791\times10^{-12}$
$C(0,7)= 6.9726\times10^{-13}$, $C(8,0)=-5.2820\times10^{-15}$, $C(6,2)= 1.9971\times10^{-14}$
$C(4,4)= 5.8846\times10^{-14}$, $C(2,6)= 4.7753\times10^{-14}$, $C(0,8)= 6.6631\times10^{-15}$
〔第2反射ミラー(M2)〕
s16$ r16= -95.46469
XDE=0.000000, YDE=-194.056296, ZDE=5.290871, ADE=63.913454
K=0.000000
$C(0,1)= 2.6001$, $C(2,0)= 2.8186\times10^{-3}$, $C(0,2)=-9.0120\times10^{-4}$
$C(2,1)=-1.4514\times10^{-4}$, $C(0,3)= 1.0385\times10^{-4}$, $C(4,0)= 1.4821\times10^{-7}$
$C(2,2)= 1.1660\times10^{-5}$, $C(0,4)=-2.5919\times10^{-7}$, $C(4,1)=-2.2429\times10^{-8}$
$C(2,3)=-5.5819\times10^{-7}$, $C(0,5)=-5.0997\times10^{-8}$, $C(6,0)= 6.0417\times10^{-11}$
$C(4,2)= 1.7171\times10^{-9}$, $C(2,4)= 1.3392\times10^{-8}$, $C(0,6)= 6.7092\times10^{-10}$
$C(6,1)=-4.0241\times10^{-12}$, $C(4,3)=-3.8374\times10^{-11}$, $C(2,5)=-1.5583\times10^{-10}$
$C(0,7)=-2.4608\times10^{-12}$, $C(8,0)= 4.3528\times10^{-15}$, $C(6,2)= 6.1025\times10^{-14}$
$C(4,4)= 2.9147\times10^{-13}$, $C(2,6)= 7.1407\times10^{-13}$, $C(0,8)= 5.1111\times10^{-16}$
〔2次像面(I2)〕
s17 r17= ∞
XDE=0.000000, YDE=-538.425624, ZDE=792.252066, ADE=12.177415

【0042】

〔各ﾌｫｰｶｽﾎﾟｼﾞｼｮﾝ(i), (ii)での面頂点座標(YDE, ZDE)〕
s6…YDE=(i)0.34320, (ii)0.29510; ZDE=(i)54.79300, (ii)54.19310
s17…YDE=(i)-538.42562, (ii)-600.85012; ZDE=(i)792.25207, (ii)900.87289

【0043】

〔各ﾌｨｰﾙﾄﾞﾎﾟｼﾞｼｮﾝに対応する1次像面(I1)側の物高〕
(x, y)=(0.00000, 0.00000), (0.00000, 9.00000), (0.00000, 4.50000),
(0.00000, -4.50000), (0.00000, -9.00000), (6.00000, 9.00000),
(6.00000, 0.00000), (6.00000, -9.00000), (12.00000, 9.00000),

(12.00000, 4.50000), (12.00000, 0.00000), (12.00000, -4.50000), (12.00000, -9.00000)

【0044】

【表1】

〈条件式対応値等〉

	(1), (3)	(2)	(4)	関連データ			
	θo	S1/S	fs×βy/S	S1	S	fs	βy
実施例1	44.98	0.77713	-1.394274	1400	1801.5	31.28	-80.3
実施例2	41.94	0.68916	-1.481432	899.7	1305.5	49.59	-39
実施例3(i)	41.96	0.66418	-1.111026	899.1	1353.7	37.32	-40.3
実施例3(ii)	41.97	0.69214	-1.138337	1024.3	1479.9	37.32	-45.14

【0045】

【発明の効果】以上説明したように本発明によれば、斜め投影角度を十分にとりながらコンパクト化を達成した、製造容易で高性能な斜め投影光学系を実現することができる。

【図面の簡単な説明】

【図1】第1の実施の形態(実施例1)の光路図。

【図2】第1の実施の形態(実施例1)の光学構成及び投影光路要部を示す図。

【図3】実施例1のスポットダイアグラム。

【図4】実施例1の歪曲図。

【図5】第2の実施の形態(実施例2)の光路図。

【図6】第2の実施の形態(実施例2)の光学構成及び投影光路要部を示す図。

【図7】実施例2のスポットダイアグラム。

【図8】実施例2の歪曲図。

【図9】第3の実施の形態(実施例3)のフォーカスポジション(i)での光路図。

【図10】第3の実施の形態(実施例3)のフォーカスポジション(ii)での光路図。

【図11】第3の実施の形態(実施例3)のフォーカスポジション(i)での光学構成及び投影光路要部を示す図。

【図12】第3の実施の形態(実施例3)のフォーカスポジション(ii)での光学構成及び投影光路要部を示す図。

【図13】実施例3のフォーカスポジション(i)でのスポットダイアグラム。

【図14】実施例3のフォーカスポジション(ii)でのスポットダイアグラム。

【図15】実施例3のフォーカスポジション(i)での歪曲図。

【図16】実施例3のフォーカスポジション(ii)での歪曲図。

【符号の説明】

I1 …1次像面

I2 …2次像面

Pr …プリズムブロック

G1 …第1屈折レンズ群

G2 …第2屈折レンズ群

G3 …第3屈折レンズ群

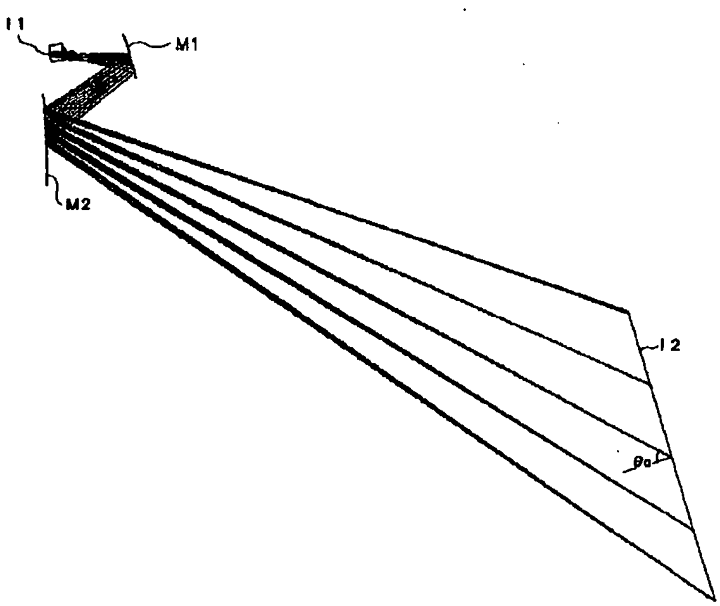
G4 …第4屈折レンズ群

ST …絞り

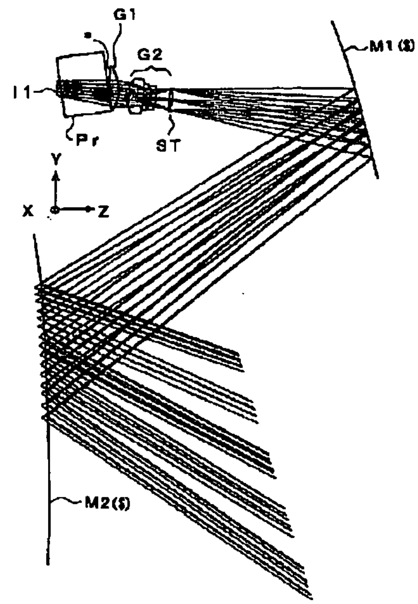
M1 …第1反射ミラー

M2 …第2反射ミラー

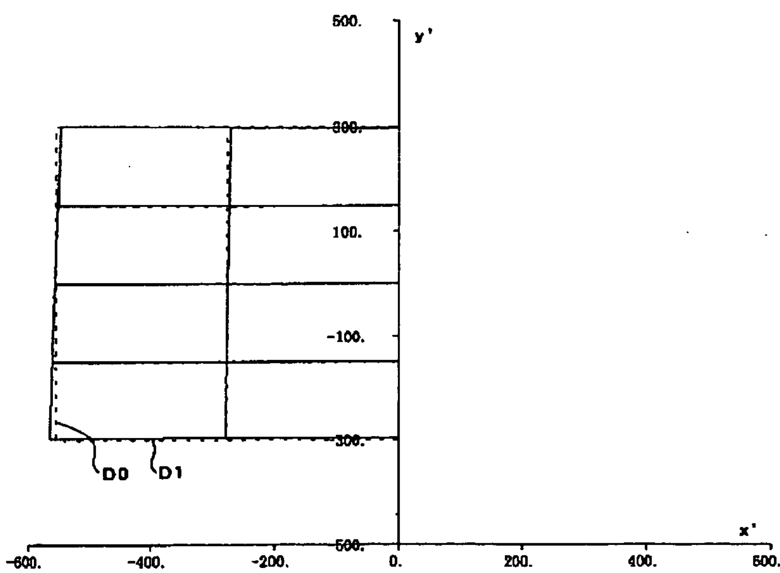
【図1】


I1
M1
M2
I2
θ0

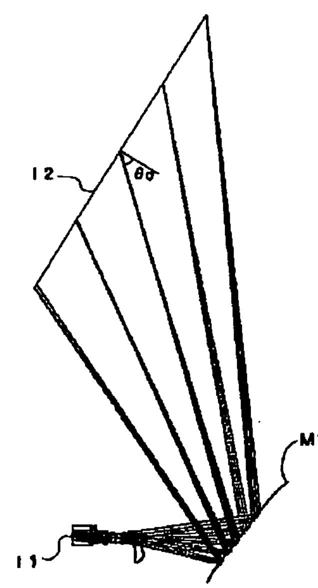
【図2】


G1
G2
M1(S)
I1
Pr
ST
Y
X
Z
M2(S)

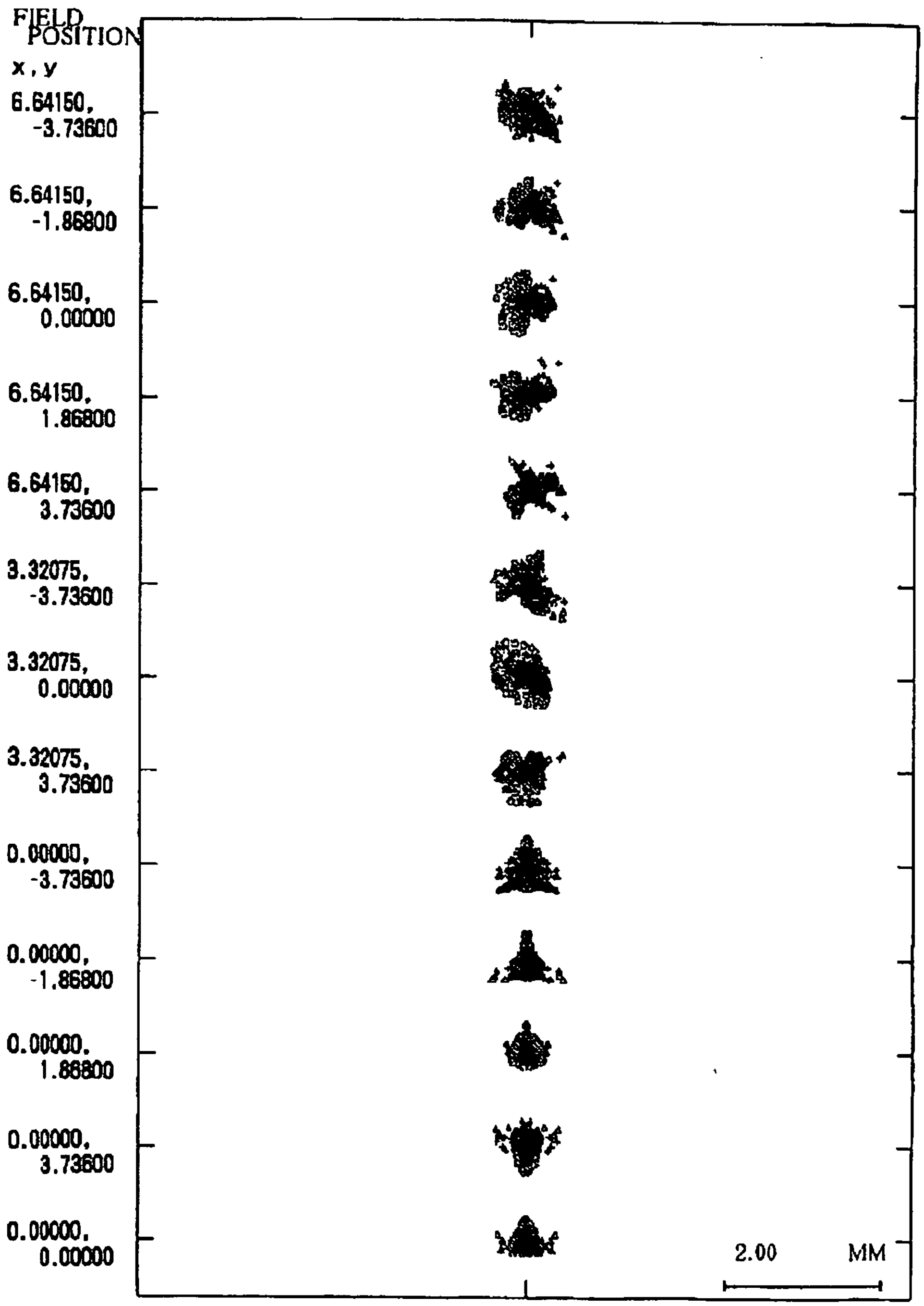
【図4】


500.
y'
300.
100.
-100.
-300.
-500.
D0
D1
x'
-600.
-400.
-200.
0.
200.
400.
600.

【図5】


I2
θ0
M1
I1

【図3】


FIELD
POSITION
x, y
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-3.73600
6.64150,
-1.86800
6.64150,
0.00000
6.64150,
1.86800
6.64150,
3.73600
3.32075,
-3.73600
3.32075,
0.00000
3.32075,
3.73600
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-3.73600
0.00000,
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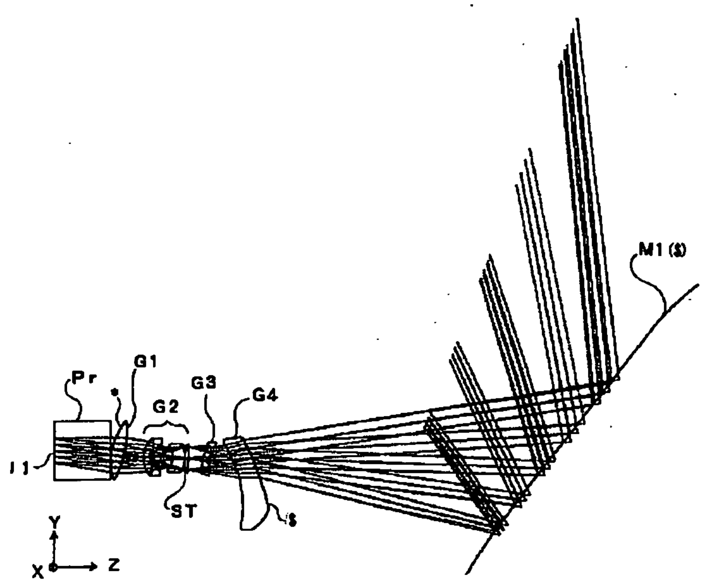
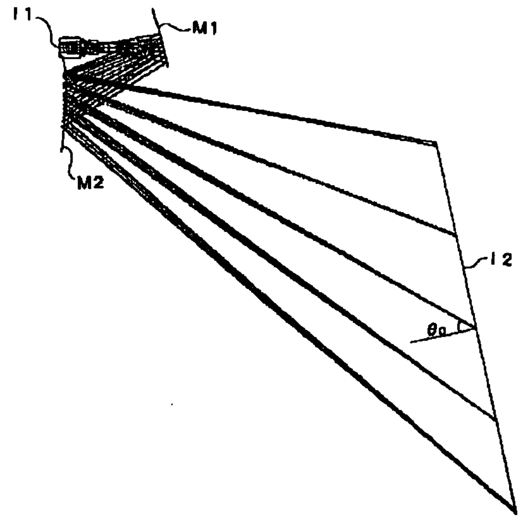
1.86800
0.00000,
3.73600
0.00000,
0.00000
2.00 MM

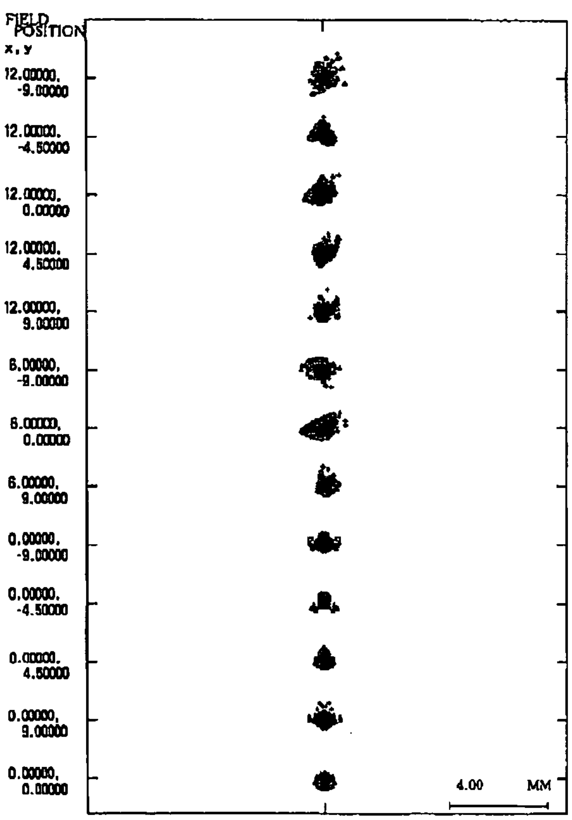
【図6】


Pr
G1
G2
G3
G4
M1(S)
I1
ST
S
Y
X
Z

【図9】


I1
M1
M2
I2
θ0

【図7】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x, y
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12.00000, 0.00000
12.00000, 4.50000
12.00000, 9.00000
6.00000, -9.00000
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6.00000, 9.00000
0.00000, -9.00000
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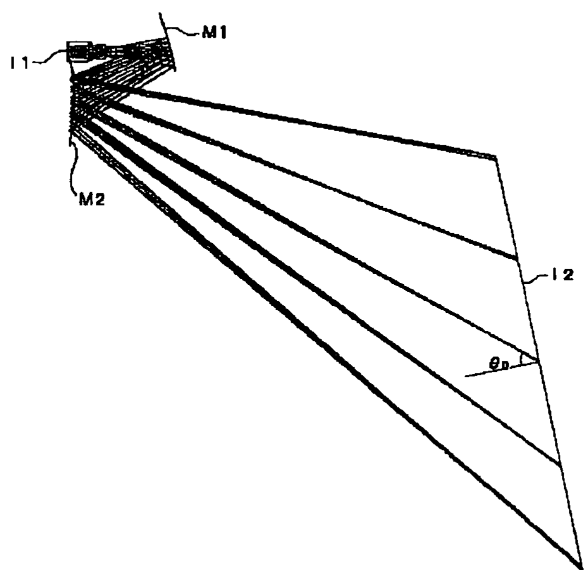
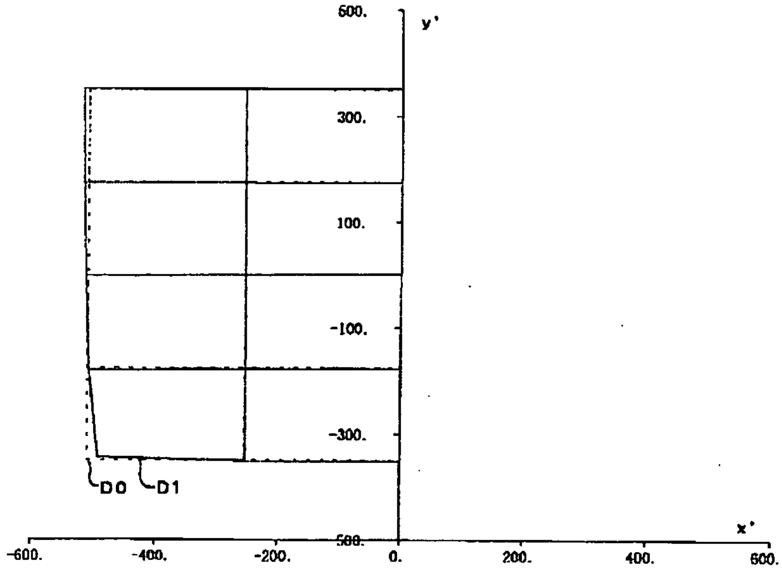
0.00000, 9.00000
0.00000, 0.00000
4.00 MM

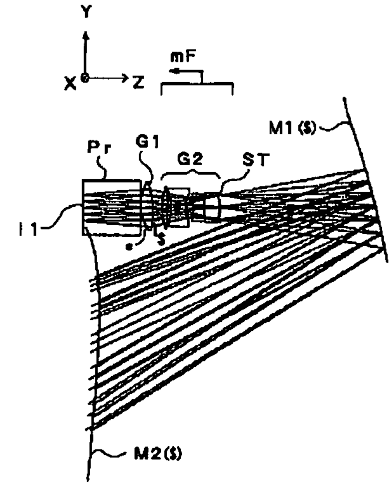
【図10】


M1
I1
M2
I2
θ0

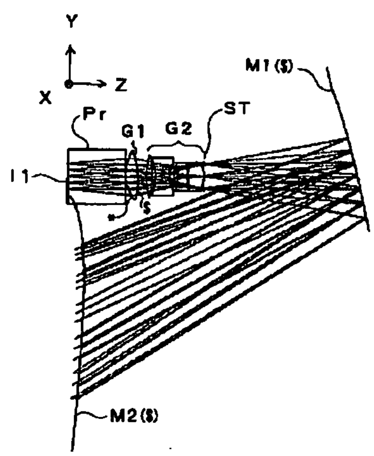
【図8】



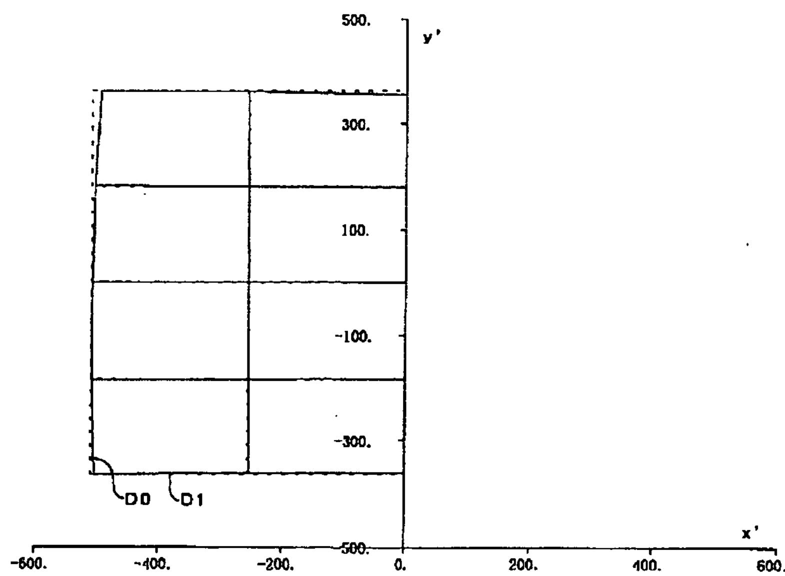
【図11】



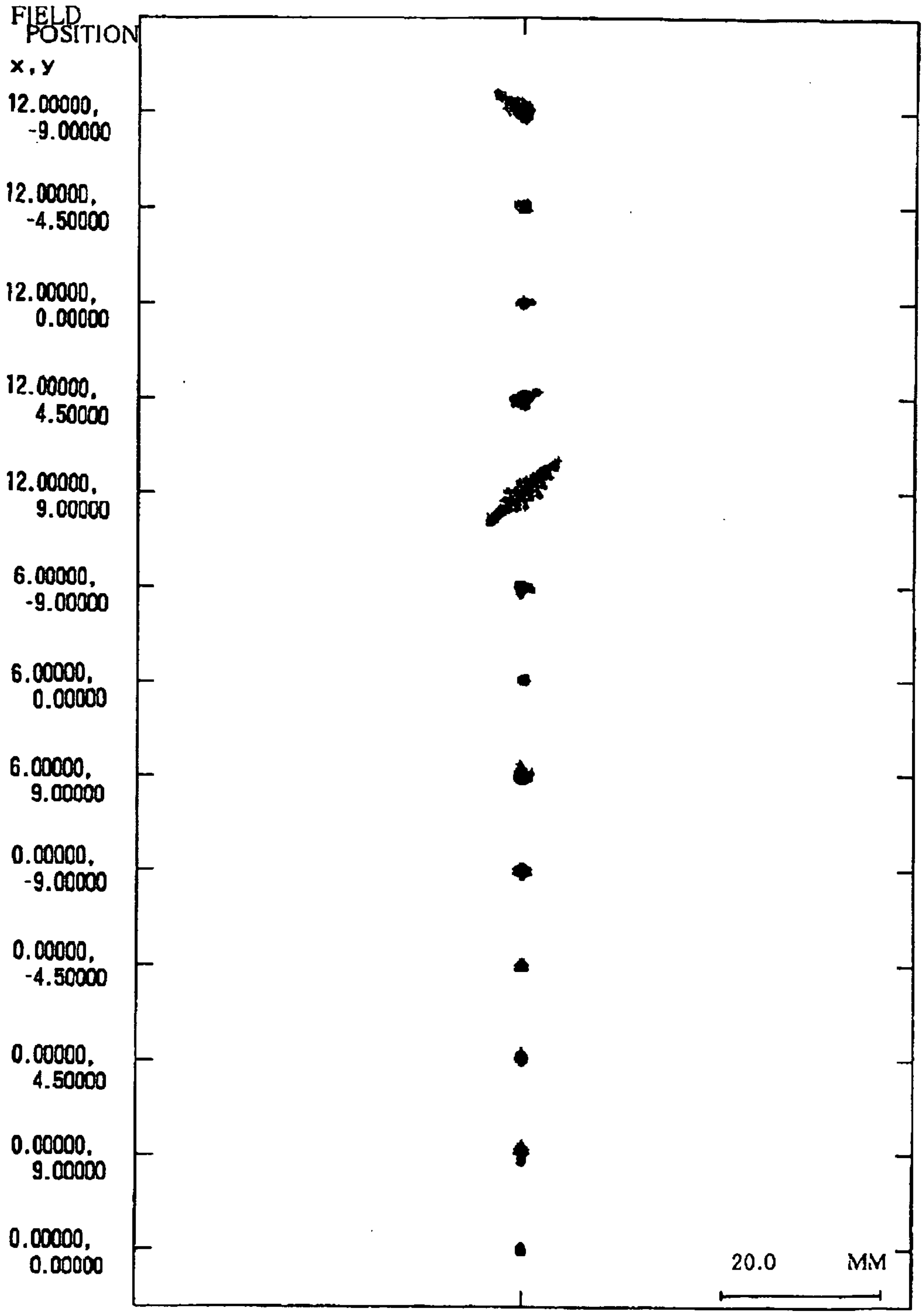
【図12】



【図15】



【図13】


FIELD
POSITION
x,y
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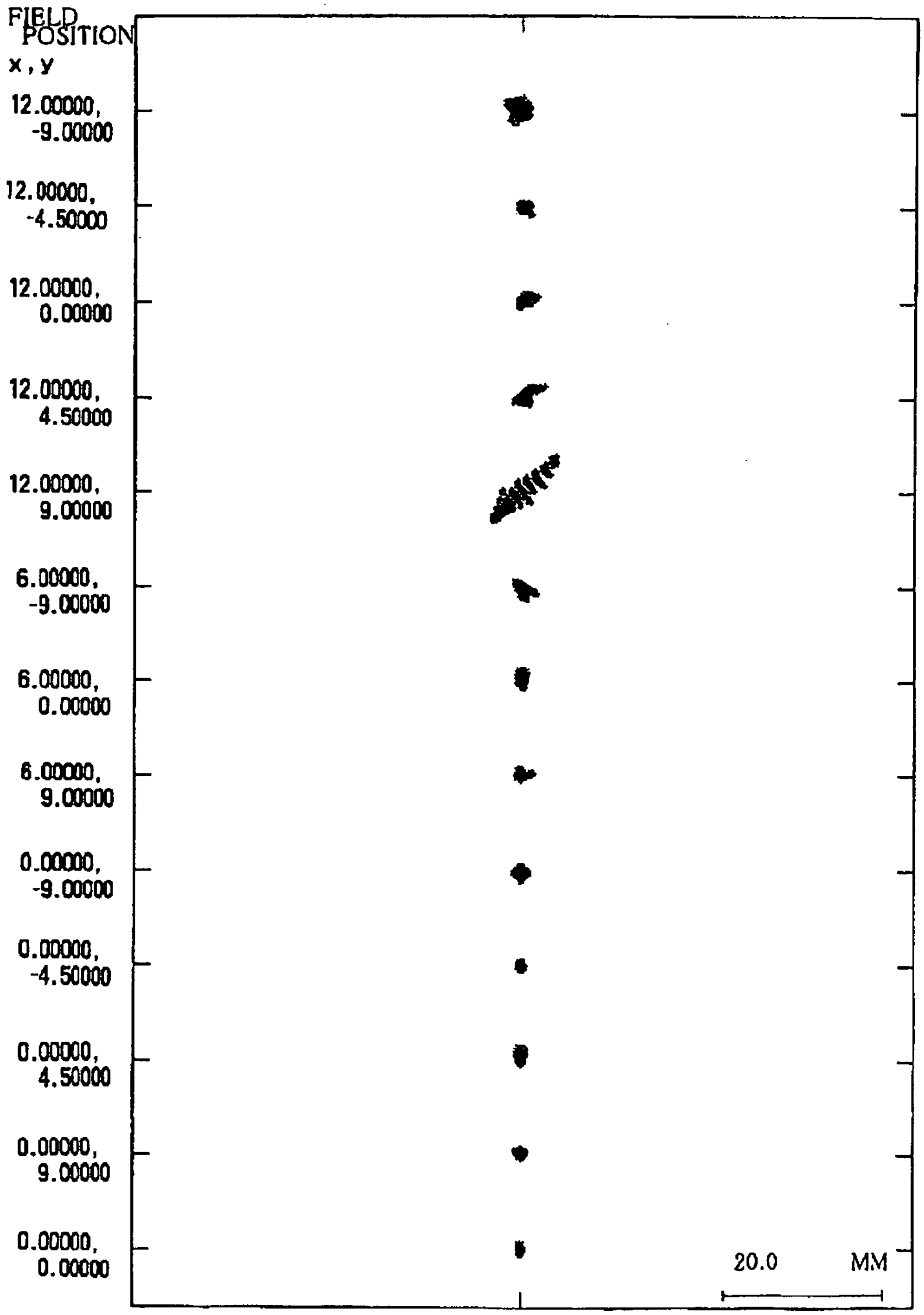
-9.00000
12.00000,
-4.50000
12.00000,
0.00000
12.00000,
4.50000
12.00000,
9.00000
6.00000,
-9.00000
6.00000,
0.00000
6.00000,
9.00000
0.00000,
-9.00000
0.00000,
-4.50000
0.00000,
4.50000
0.00000,
9.00000
0.00000,
0.00000
20.0 MM

【図14】


FIELD
POSITION
x, y
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-9.00000
12.00000,
-4.50000
12.00000,
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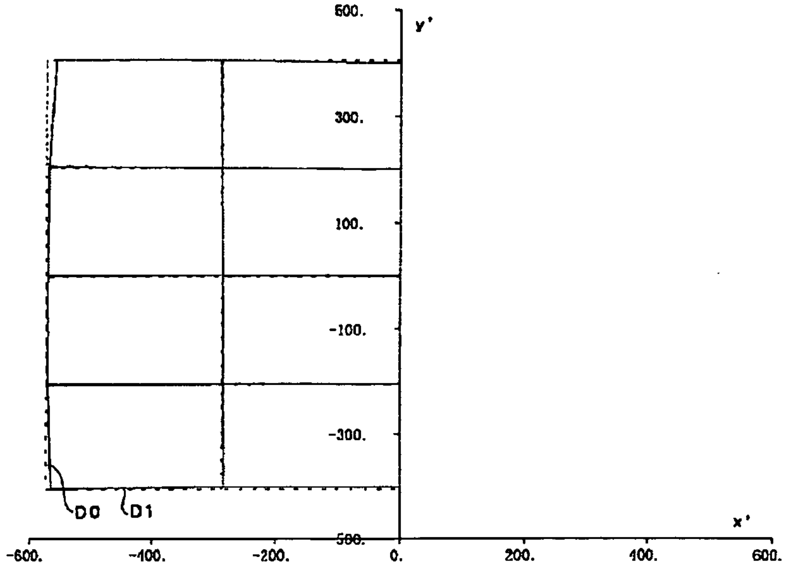
12.00000,
4.50000
12.00000,
9.00000
6.00000,
-9.00000
6.00000,
0.00000
6.00000,
9.00000
0.00000,
-9.00000
0.00000,
-4.50000
0.00000,
4.50000
0.00000,
9.00000
0.00000,
0.00000
20.0
MM

【図16】



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[Theme code (reference)]

2H087

[F term (reference)]

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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

Epitome

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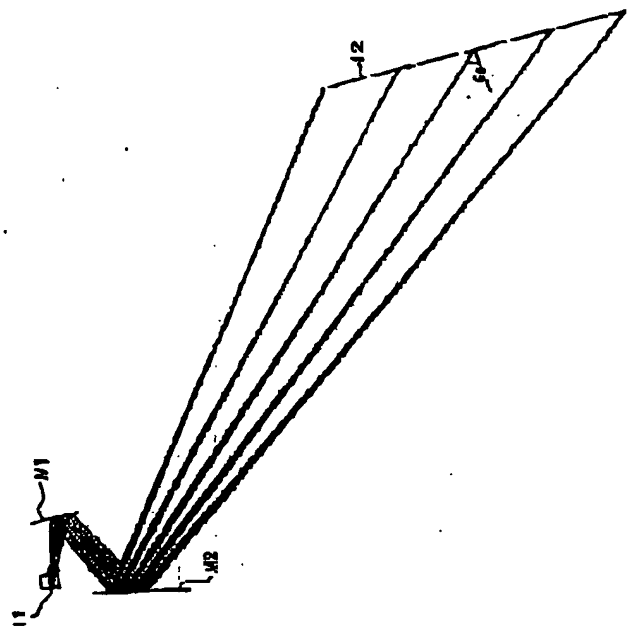
(57) [Abstract]
[Technical problem] the manufacture which attained miniaturization while fully taking the slanting projection include angle — easy and highly efficient slanting projection optics is offered.
[Means for Solution] Expansion projection is carried out from the primary image surface (I1) in the direction of slant to the secondary image surface (I2). It has the page [1st / or more] reflector which has two or more the dioptric lens groups and power which carried out eccentricity mutually. When making into a photograph center beam of light the beam of light which extracts from an image surface (I1) core, and reaches through the (ST) core centering on the image surface (I2), 10 degree<thetao<70 degree, 0.40<S1/S< 0.9 [the optical path length of the photograph center beam of light to the optical surface where a thetao:photograph center beam of light has the optical path length of the normal of the image surface (I2), and the include angle to make and the photograph center beam of light from S:image surface (I1) to the image surface (I2) and the power of the S1:image surface (I2) to the beginning] is filled.

[Translation done.]



[Translation done.]

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CLAIMS

[Claim(s)]
[Claim 1] While being the slanting projection optics which performs expansion projection of the direction of slant from the primary image surface to the secondary image surface by the side of expansion by the side of contraction and having two or more dioptric lens groups which carried out eccentricity mutually When making into a photograph center beam of light the beam of light which arrives at the photograph center of said secondary image surface through the core of a diaphragm from the bottom of its heart among the screen of said primary image surface, without having the 1st [or more] page of the reflector which has power, and carrying out image formation of the middle real image even to said secondary image surface from said primary image surface, Slanting projection optics characterized by filling the following conditional expression; 10 degrees -- < -- thetao<70 degree0.40 -- < -- S1/S< 0.9 however the include angle that a thetao:photograph center beam of light makes with the normal of the secondary image surface, and S : the optical path length of the photograph center beam of light from the primary image surface to the secondary image surface, and the optical path length of the photograph center beam of light to an optical surface who has the first power from S 1:2nd image surface -- it comes out.

[Claim 2] Slanting projection optics according to claim 1 characterized by arranging only the refracting interface between said primary image surfaces and said diaphragms.
[Claim 3] Slanting projection optics according to claim 1 characterized by the 1st [or more] page of said reflectors having a free sculptured surface configuration.
[Claim 4] Slanting projection optics according to claim 1 characterized by arranging the reflective mirror which constitutes said reflector the 2nd page from said drawing at the secondary image surface side, for the reflective mirror by the side of a diaphragm having forward power, and the reflective mirror by the side of the secondary image surface having negative power.
[Claim 5] Slanting projection optics according to claim 1 characterized by for the dioptric lens most arranged among the dioptric lenses which constitute said dioptric lens group at the primary image surface side having forward power, and filling the following conditional expression;
- 1.7< fsxbeta y/S -- < -0.8, however fs: -- the magnifying power of the focal distance [of the forward dioptric lens by the side of the primary image surface], and betay:slantingest projection direction -- come out.
[Claim 6] Slanting projection optics according to claim 1 characterized by performing a focus by moving some optical elements.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the suitable slanting projection optics for image projection equipment which performs expansion projection of the direction of slant from the primary image surface to the secondary image surface about slanting projection optics.
[0002]
[Description of the Prior Art] In the image projection equipment which carries out expansion projection of the image displayed on the liquid crystal display (LCD:liquid crystal display) etc. at a screen, although enlargement of a screen is attained, the equipment which carries out expansion projection of the image from across at a screen is variously proposed in order to use the whole projection equipment as a compact. As the concrete example, the equipment (JP,10-111474,A) which constituted all the optical elements of projection optics from a reflective mirror, the equipment (JP,10-282451,A) which constituted all the optical elements of projection optics from a dioptric lens, and the equipment (JP,9-179064,A) which has the projection optics with which the reflective mirror and the dioptric lens were combined are mentioned.
[0003]
[Problem(s) to be Solved by the Invention] A component can be lessened, if all optical elements are constituted from a reflective mirror as proposed by JP,10-111474,A. However, since there is no degree of freedom of chromatic-aberration amendment in a reflective mirror, with the configuration of colorization by the multi-plate type, constraint will arise in arrangement of the

optical element for color composition. Moreover, although it is necessary to cast a mirror by plastics in order to obtain the curved-surface mirror of a major diameter by low cost, it is difficult to form an efficient reflective coat on a plastics side. For this reason, when the mirror made from plastics is used for the projector of high brightness, the temperature of a mirror will rise, a reflector configuration will deform and aggravation of aberration and the fall of endurance will be caused.

[0004] If all optical elements are constituted from a dioptric lens as proposed by JP,10-282451,A, slanting projection can be attained by the optical element of a comparatively small area. However, many lens groups which carried out eccentricity are need, and in order to carry out eccentricity of some of them greatly, maintenance of an optical element is difficult for them. If a reflective mirror and a dioptric lens are combined as proposed by JP,9-179064,A, there will be few lens groups which carried out eccentricity, it will end, and the configuration of projection optics will also become easy. However, while having power, a mirror with difficult, very large manufacture of area is needed.

[0005] the manufacture which attained miniaturization while this invention was made in view of such a situation and the slanting projection include angle was fully taken — it aims at offering easy and highly efficient slanting projection optics.

[0006]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the slanting projection optics of the 1st invention While being the slanting projection optics which performs expansion projection of the direction of slant from the primary image surface to the secondary image surface by the side of expansion by the side of contraction and having two or more dioptric lens groups which carried out eccentricity mutually When making into a photograph center beam of light the beam of light which arrives at the photograph center of said secondary image surface through the core of a diaphragm from the bottom of its heart among the screen of said primary image surface, without having the 1st [or more] page of the reflector which has power, and carrying out image formation of the middle real image even to said secondary image surface from said primary image surface, it is characterized by filling the following conditional expression.

10 degrees --- < — thetao<70 degree0.40 — < — S1/S< 0.9 however the include angle that a thetao:photograph center beam of light makes with the normal of the secondary image surface, and S : the optical path length of the photograph center beam of light from the primary image surface to the secondary image surface, and the optical path length of the photograph center beam of light to an optical surface who has the first power from S 1:2nd image surface -- it comes out.

[0007] Slanting projection optics of the 2nd invention is characterized by arranging only the refracting interface between said primary image surfaces and said diaphragms in the configuration of invention of the above 1st.

[0008] Slanting projection optics of the 3rd invention is characterized by the 1st [or more] page of said reflectors having a free sculptured surface configuration in the configuration of invention of the above 1st.

[0009] Slanting projection optics of the 4th invention is characterized by arranging the reflective mirror which constitutes said reflector from said drawing in a secondary image surface side the 2nd page, for the reflective mirror by the side of a diaphragm having forward power, and the reflective mirror by the side of the secondary image surface having negative power in the configuration of invention of the above 1st.

[0010] Slanting projection optics of the 5th invention is characterized by for the dioptric lens most arranged among the dioptric lenses which constitute said dioptric lens group at the primary image surface side having forward power, and filling the following conditional expression in the configuration of invention of the above 1st.

- 1.7< fsxbeta y/S — < -0.8, however fs: — the magnifying power of the focal distance [of the forward dioptric lens by the side of the primary image surface], and betay:slantingest projection direction -- come out.

[0011] Slanting projection optics of the 6th invention is characterized by performing a focus by

moving some optical elements in the configuration of invention of the above 1st.
[0012]
[Embodiment of the Invention] Hereafter, the slanting projection optics which carried out this invention is explained, referring to a drawing. The whole projection optical path from the primary image surface (I1) of the gestalt of the 1st operation to the secondary image surface (I2) is shown in drawing 1 , and the optical configuration and projection optical-path important section of a gestalt of the 1st operation are shown in drawing 2 . The whole projection optical path from the primary image surface (I1) of the gestalt of the 2nd operation to the secondary image surface (I2) is shown in drawing 5 , and the optical configuration and projection optical path important section of a gestalt of the 2nd operation are shown in drawing 6 . Moreover, drawing 9 and the whole projection optical path from the primary image surface (I1) of the gestalt of the 3rd operation to drawing 10 to the secondary image surface (I2) are shown about each focal position (i) and (ii). and the optical configuration and projection optical-path important section of a gestalt of the 3rd operation are shown in drawing 11 and drawing 12 about each focal position (i) and (ii). In addition, these optical-path Figs. show Y-Z-section configuration in the below-mentioned rectangular coordinate system (X, Y, Z), and it is shown among drawing 2 , drawing 6 , drawing 11 , and drawing 12 that the field where, as for the field where * mark was attached, the aspheric surface and $ mark were attached is a free sculptured surface.
[0013] The gestalt of each operation is slanting projection optics for image projection equipments which performs expansion projection of the direction of slant from the primary image surface (I1) to the secondary image surface by the side of expansion by the side of contraction (I2). Therefore, the primary image surface (I1) is equivalent to the screen of the display device (for example, LCD) which displays a two-dimensional image, and the secondary image surface (I2) is equivalent to a projection image side (that is, screen side). In addition, it is also possible to use for an image reader the gestalt of each operation as slanting projection optics which performs contraction projection of the direction of slant from the secondary image surface (I2) to the primary image surface (I1). In that case, the primary image surface (I1) is equivalent to the light-receiving side of the photo detector [for example, CCD (Charge Coupled Device)] which performs image reading, and the secondary image surface (I2) is equivalent to a reading image side (that is, manuscript sides, such as a film).
[0014] The gestalt (drawing 1 , drawing 2) of the 1st operation sequentially from a primary image surface (I1) side (contraction side) A prism block (Pr), The 1st dioptric lens group (G1) which consists of one dioptric lens which carried out eccentricity, and the 2nd dioptric lens group which consists of four dioptric lenses which accomplish a coaxial system (G2), it comes out with drawing (ST), the 1st reflective mirror (M1) which has forward power, and the 2nd reflective mirror (M2) which has negative power, and is constituted. The contraction side face of the dioptric lens which constitutes the 1st dioptric lens group (G1) consists of the aspheric surface, and the reflector of the 1st and 2nd reflective mirror (M1, M2) consists of the free sculptured surface.
[0015] The gestalt (drawing 5 , drawing 6) of the 2nd operation sequentially from a primary image surface (I1) side (contraction side) A prism block (Pr), The 1st dioptric lens group (G1) which consists of one dioptric lens which carried out eccentricity, and the 2nd dioptric lens group which consists of four dioptric lenses which accomplish a coaxial system (G2), it comes out with the 3rd dioptric lens group (G3) which consists of one dioptric lens which carried out eccentricity to drawing (ST), the 4th dioptric lens group (G4) which consists of one dioptric lens which carried out eccentricity, and the 1st reflective mirror (M1) which has negative power, and is constituted. The contraction side face of the dioptric lens which constitutes the 1st dioptric lens group (G1) consists of the aspheric surface, the expansion side face of the dioptric lens which constitutes the 4th dioptric lens group (G4) consists of the free sculptured surface, and the reflector of the 1st reflective mirror (M1) consists of the free sculptured surface.
[0016] The gestalt (drawing 9 - drawing 12) of the 3rd operation sequentially from a primary image surface (I1) side (contraction side) A prism block (Pr), The 1st dioptric lens group (G1) which consists of one dioptric lens which carried out eccentricity, and the 2nd dioptric lens group which consists of four dioptric lenses which accomplish a coaxial system (G2), it comes

out with drawing (ST). the 1st reflective mirror (M1) which has forward power. and the 2nd reflective mirror (M2) which has negative power, and is constituted. In the aspheric surface and an expansion side face, the contraction side face of the dioptric lens which constitutes the 1st dioptric lens group (G1) consists of the free sculptured surface, and the reflector of the 1st and 2nd reflective mirror (M1, M2) consists of the free sculptured surface. The focus of the gestalt of the 3rd operation is performed when the 2nd dioptric lens group (G2) carries out a parallel displacement. For example, in the focal position (i) shown in drawing 9 and drawing 11 , if the 2nd dioptric lens group (G2) is moved in the arrow-head mF direction (drawing 11), it will become the focal position (ii) shown in drawing 10 and drawing 12 . In addition, it extracts at the time of a focus and (ST) moves with the 2nd dioptric lens group (G2).

[0017] While having two or more dioptric lens groups (G1, G2, --) which carried out eccentricity mutually like the gestalt of each operation, it is desirable to consider as the configuration which is equipped with the 1st [or more] page (M1,) of the reflector which has power, and does not carry out image formation of the middle real image even to the secondary image surface (I2) from the primary image surface (I1). While this holds high optical-character ability, it becomes possible to use slanting projection optics as a thin compact. With the multi-plate configuration for the colorization used for a projector, although glass blocks, such as a cross dichroic prism, are generally needed, if projection light passes aslant to the plane of incidence and the injection side of a glass block, chromatic aberration will occur. If it has the dioptric lens group (G1, G2, --) as mentioned above, amendment of chromatic aberration is possible. Moreover, since it becomes possible to illuminate a reflective mold display device (for example, the reflective mold LCD) from across, it becomes unnecessary to use a polarization beam splitter (PBS) etc., and low cost-ization can be attained.

[0018] one -- order -- the image surface (I1) -- a screen -- inside -- from the bottom of its heart -- extracting -- (-- ST --) -- a core -- a passage -- two -- order -- the image surface (I2) -- a photograph center -- reaching -- a beam of light -- " -- a photograph center -- a beam of light -- " -- ** -- carrying out -- the time -- one -- order the image surface (I1) -- two -- order -- the image surface (I2) -- between -- middle -- a real image -- image formation nothing -- the following -- conditional expression -- (-- one --) -- and -- (-- two --) -- filling -- things -- being desirable .

10degree<theta -- o< 70 degrees --(1) 0.40 -- < -- S1/S< 0.9 -- (2) however the include angle which a thetao:photograph center beam of light makes with the normal of the secondary image surface (I2), and S : the optical path length of the photograph center beam of light from the primary image surface (I1) to the secondary image surface (I2), and the optical path length of the photograph center beam of light to an optical surface who has the first power from S 1:2nd image surface (I2) -- it comes out.

[0019] If the upper limit of conditional expression (1) is exceeded, it will become difficult to amend the keystone distortion by slanting projection. If the minimum of conditional expression (1) is exceeded, the effectiveness of thin-shape-izing by slanting projection will become small. If the upper limit of conditional expression (2) is exceeded, projection distance will become long too much and the effectiveness of thin-shape-izing will become small. If the minimum of conditional expression (2) is exceeded, the path of the optical element near the secondary image surface by the side of expansion (I2) will become excessive, and the manufacture will become difficult with a cost rise.

[0020] It is desirable to fill the following conditional expression (3) furthermore.

40 degree<thetao<60 degree --- (3) [0021] Conditional expression (3) has specified the still more desirable condition range of include-angle thetao. If the upper limit of conditional expression (3) is exceeded, in order to amend a keystone distortion and a curvature of field, many free sculptured surfaces will be needed, and the part cost will become high. Furthermore, since whenever [over a projection screen / incident angle] becomes large, it will be necessary to bend light greatly in the direction of an observer in a screen. Therefore, the structure of a screen becomes complicated and cost becomes high. If the minimum of conditional expression (3) is exceeded, effective thin shape-ization by slanting projection will become difficult.

[0022] Like the gestalt of each operation, it is desirable for a page [1st / or more] reflector to

have a free sculptured surface configuration. rotation which does not have a symmetry axis of rotation inversion in a service area while including the aspheric surface which carried out eccentricity to the free sculptured surface configuration greatly — it is an unsymmetrical field configuration (the reflector used for the gestalt of each operation has a symmetrical free sculptured surface configuration to a Y-Z flat surface.). Although aberration amendment symmetrical with a non-shaft is needed in slanting projection, the aberration amendment symmetrical with a non-shaft by slanting projection is attained at few optical elements by using the 1st [or more] page of the reflector which has a free sculptured surface configuration. Moreover, it is still more desirable to use the free sculptured surface of the 2nd [or more] page. Since an assignment of aberration amendment is attained at the free sculptured surface [the free sculptured surface close to the secondary image surface (I2)] which mainly amends the keystone distortion of slanting projection by using the 2nd [or more] page of the reflector which has a free sculptured surface configuration, and the free sculptured surface [the free sculptured surface which extracted and approached (ST)] which amends the unsymmetrical curvature of field and the unsymmetrical astigmatic difference by slanting projection, more highly efficient projection optics can be attained.

[0023] By the way, to constitute projection optics only from a reflective mirror, it is necessary to make as many mirror sides as possible into a free sculptured surface configuration. Although forming with plastics generally is advantageous in cost as for a free sculptured surface or the aspheric surface. It is difficult the aspheric surface to form multilayer dielectric multilayers on a plastics side. For this reason, by the free sculptured surface mirror which consisted of plastics, that reflection factor becomes 95% or less by average in a visible region. Since several% of remaining light is absorbed by the plastics side and becomes heat, the temperature of a reflective mirror will rise. Since the reflective mirror made from plastics has low thermal resistance, by the temperature rise, a reflector configuration will deform and it will cause aggravation of aberration, and the fall of endurance.

[0024] In especially the field that extracts near the primary image surface (I1), and is applied near the (ST), since light will concentrate, the problem of the above-mentioned heat is serious and it is impossible to arrange the free sculptured surface mirror made from plastics to the field. In order to solve this problem, it is desirable to arrange the optical element of refractive media, such as a plastic lens, a glass lens, etc. which have the aspheric surface or a free sculptured surface to the field which extracts near the primary image surface (I1), and is applied near the (ST). If it is the optical element of refractive media, since the transmission will be stopped to about 99% by the 1st page, even if it constitutes a free sculptured surface from plastics, the problem of the above-mentioned heat is avoidable. Moreover, to the field which extracts near the primary image surface (I1), and is applied near the (ST), the free sculptured surface mirror obtained by glass molding may be arranged. Since thermal resistance is higher than plastics, glass can avoid the problem of the above-mentioned heat.

[0025] With the configuration with which it extracted as the primary image surface (I1), and only the refracting interface has been arranged between (STs) like the gestalt of each operation, the problem of the above-mentioned heat is avoidable from a viewpoint mentioned above. Since a refracting interface excels a reflector in thermal resistance, if the optical element (the plastic lens and glass lens which have the aspheric surface or a free sculptured surface) of the refractive media which extract as the primary image surface (I1), and constitute a refracting interface between (STs) is used, it will become possible [performing brighter lighting], avoiding the problem of the above-mentioned heat. Moreover, it is effective in arrangement of the illumination-light study system which illuminates the primary image surface (I1) becoming easy by extracting as the primary image surface (I1), and not carrying out the clinch of the beam of light by the reflective mirror in this field, although it is the field which is spatially hard-pressed between (STs).

[0026] In the configuration to extract and by which the 2nd page (M1, M2) of a reflective mirror has been arranged from (ST) like the gestalt of the 1st and the 3rd operation at the secondary image surface (I2) side, it is desirable to extract, for the 1st reflective mirror by the side of (ST) (M1) to have forward power, and for the 2nd reflective mirror (M2) by the side of the secondary

image surface (I2) to have negative power. By just carrying out power of the 1st reflective mirror (M1) near drawing (ST), the flux of light from the 1st reflective mirror (M1) to the 2nd reflective mirror (M2) can be carried out with some convergence. Therefore, since the 2nd reflective mirror (M2) can be made small, it becomes advantageous in respect of cost and the ease of manufacturing. Furthermore, by making negative power of the 2nd reflective mirror (M2), since projection of a big screen is attained also in a short projection distance, the whole projection optics can be used as a compact.

[0027] It is desirable for the dioptric lens (G1) most arranged like the gestalt of each operation among the dioptric lenses which constitute the dioptric lens group (G1, --) at the primary image surface (I1) side to have forward power, and to fill the following conditional expression (4).
- 1.7< fsxbeta y/S -- < -0.8 -- (4), however fs: -- the magnifying power of the focal distance [of the forward dioptric lens (G1) by the side of the primary image surface (I1)], and betay:slantingest projection direction -- it comes out.

[0028] Since the light from a display device separates greatly from a tele cent rucksack, while it becomes impossible to permit the color nonuniformity generated by color composition prism if the minimum of conditional expression (4) is exceeded, the overall length of projection optics will become large too much. If the upper limit of conditional expression (4) is exceeded, the curvature of field and distortion which are generated since the power of this lens becomes strong too much will become excessive, and amendment will become difficult.

[0029] It is desirable to carry out by moving some optical elements like the gestalt of the 3rd operation about a focus. The focus by display device migration is easy to produce the pixel gap accompanying a focus in a multi-plate method. Therefore, since it will be necessary to perform pixel gap adjustment to coincidence with a focus, there is a problem that working hours become long. Moreover, since the focus which moves the whole optical system has the large migration member, the focal device itself becomes large and cost becomes high. Therefore, the configuration which performs a focus by moving some optical elements (the optical element of refractive media, optical element of a reflective system) is desirable. According to this configuration, since the display device migration for the pixel gap adjustment in a multi-plate configuration and a focus become independent, a focus and pixel gap tuning become easy, and miniaturization is attained for the focal device itself. It is still more desirable to perform a focus by moving some optical elements in parallel like the gestalt of the 3rd operation (namely, parallel displacement). The migration device of a focus becomes easier by this, and cost can be made cheap.

[0030]

[Example] Hereafter, construction data, a spot diagram, etc. are mentioned and the configuration of the slanting projection optics which carried out this invention is explained still more concretely. Drawing (drawing 1 , drawing 2 ; drawing 5 , drawing 6 ; drawing 9 - drawing 12) which the examples 1-3 given as an example here are equivalent to the gestalt of the 1st - the 3rd operation mentioned above, respectively, and expresses the gestalt of each operation shows the optical path of each corresponding example etc., respectively.

[0031] In the construction data of each example si (i= 1, 2 and 3, ...) The primary image surface by the side of contraction (it is equivalent to the object surface in expansion projection.) [I1;] And the secondary image surface by the side of expansion (it is equivalent to the image surface in expansion projection.) [I2;] In the included system, it counts from a contraction side, and is the i-th field, and ri (i= 1, 2 and 3, ...) is the radius of curvature (mm) of Field si. Moreover, count di (i= 1, 2 and 3, ...) from a contraction side, and the i-th axial top-face spacing (mm and an eccentric spacing are indicated as eccentric data.) is shown. nickel (i= 1, 2 and 3, ...) and nui (i= 1, 2 and 3, ...) are counted from a contraction side, and show the refractive index (Nd) and the Abbe number (nud) to d line of the i-th optical element, respectively. In addition, the object quantity (mm) by the side of the primary image surface (I1) corresponding to each field position is shown collectively, and the value and associated data corresponding to conditional expression of each example are shown in Table 1.

[0032] * The field si where the mark was attached is the aspheric surface symmetrical with a shaft, and the field configuration is defined by the formula (AS1) of the following which used the

rectangular coordinate system (x y, z) which makes a plane peak point a zero. Moreover, the field si where $ mark was attached is a free sculptured surface, and the field configuration is defined by the formula (AS2) of the following which used the rectangular coordinate system (x y, z) which makes a plane peak point a zero. Aspheric surface data and free sculptured surface data are combined with other data, and are shown.

[0033]

z=(c-h2)/[1+root[1-c2 and h2]] + (A-h4+B-h6+C-h8+D-h10) — (AS1) [Equation 1]

$$z = (c \cdot h^2) / [1+\sqrt{\{1-(1+K) \cdot c^2 \cdot h^2\}}] + \sum_m \sum_n [C(m, n) \cdot x^m \cdot y^n] \quad \cdots (AS2)$$

[0034] however, the variation rate from the datum level of the direction of an optical axis in the location of z:height h — an amount and h:optical axis — receiving — the height (h2=x2+y2) of a perpendicular direction, c:paraxial curvature (=1-/radius of curvature), A, B and C, D:aspheric surface multiplier, K:conic constant, and O(m, n):free sculptured surface multiplier -- it comes out.

[0035] About the field which carried out eccentricity to the field in which it is located just before a contraction side, eccentric data are shown based on a rectangular coordinate system (X, Y, Z).

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The optical-path Fig. of the gestalt (example 1) of the 1st operation.
[Drawing 2] Drawing showing the optical configuration and projection optical-path important section of a gestalt (example 1) of the 1st operation.
[Drawing 3] The spot diagram of an example 1.
[Drawing 4] The distortion Fig. of an example 1.
[Drawing 5] The optical-path Fig. of the gestalt (example 2) of the 2nd operation.
[Drawing 6] Drawing showing the optical configuration and projection optical-path important section of a gestalt (example 2) of the 2nd operation.
[Drawing 7] The spot diagram of an example 2.
[Drawing 8] The distortion Fig. of an example 2.
[Drawing 9] The optical-path Fig. in the focal position (i) of the gestalt (example 3) of the 3rd operation.
[Drawing 10] The optical-path Fig. in the focal position (ii) of the gestalt (example 3) of the 3rd operation.
[Drawing 11] Drawing showing the optical configuration and projection optical-path important section in a focal position (i) of a gestalt (example 3) of the 3rd operation.
[Drawing 12] Drawing showing the optical configuration and projection optical-path important section in a focal position (ii) of a gestalt (example 3) of the 3rd operation.
[Drawing 13] The spot diagram in the focal position (i) of an example 3.
[Drawing 14] The spot diagram in the focal position (ii) of an example 3.
[Drawing 15] The distortion Fig. in the focal position (i) of an example 3.
[Drawing 16] The distortion Fig. in the focal position (ii) of an example 3.

[Description of Notations]

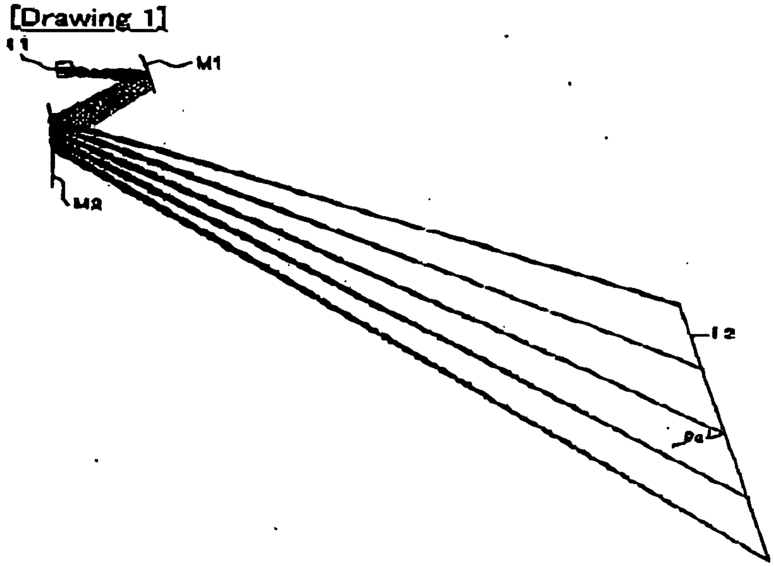
I1 — Primary image surface

I2 Secondary image surface
Pr — Prism block
G1 — The 1st dioptric lens group
G2 — The 2nd dioptric lens group
G3 — The 3rd dioptric lens group
G4 — The 4th dioptric lens group
ST — Diaphragm
M1 The 1st reflective mirror
M2 — The 2nd reflective mirror

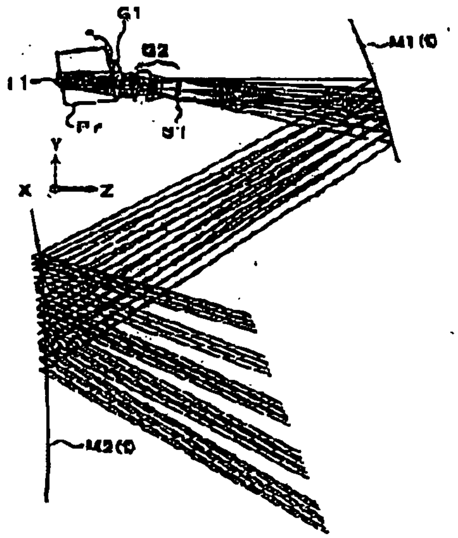
[Translation done.]

DRAWINGS

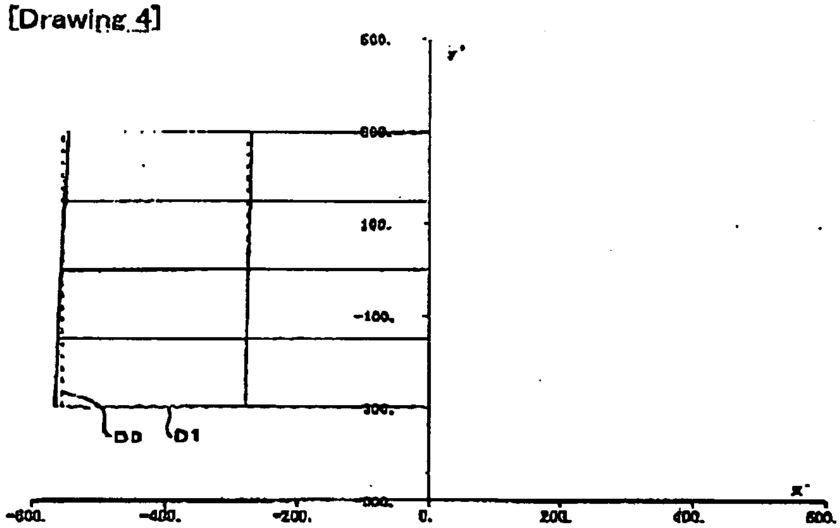
[Drawing 1]



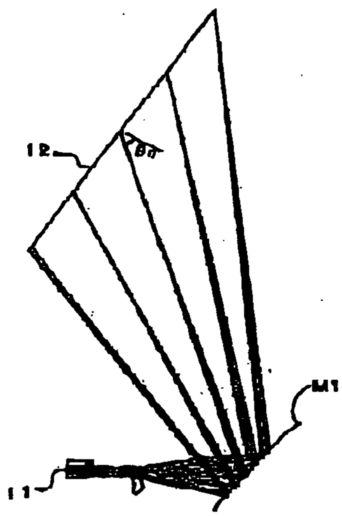
[Drawing 2]



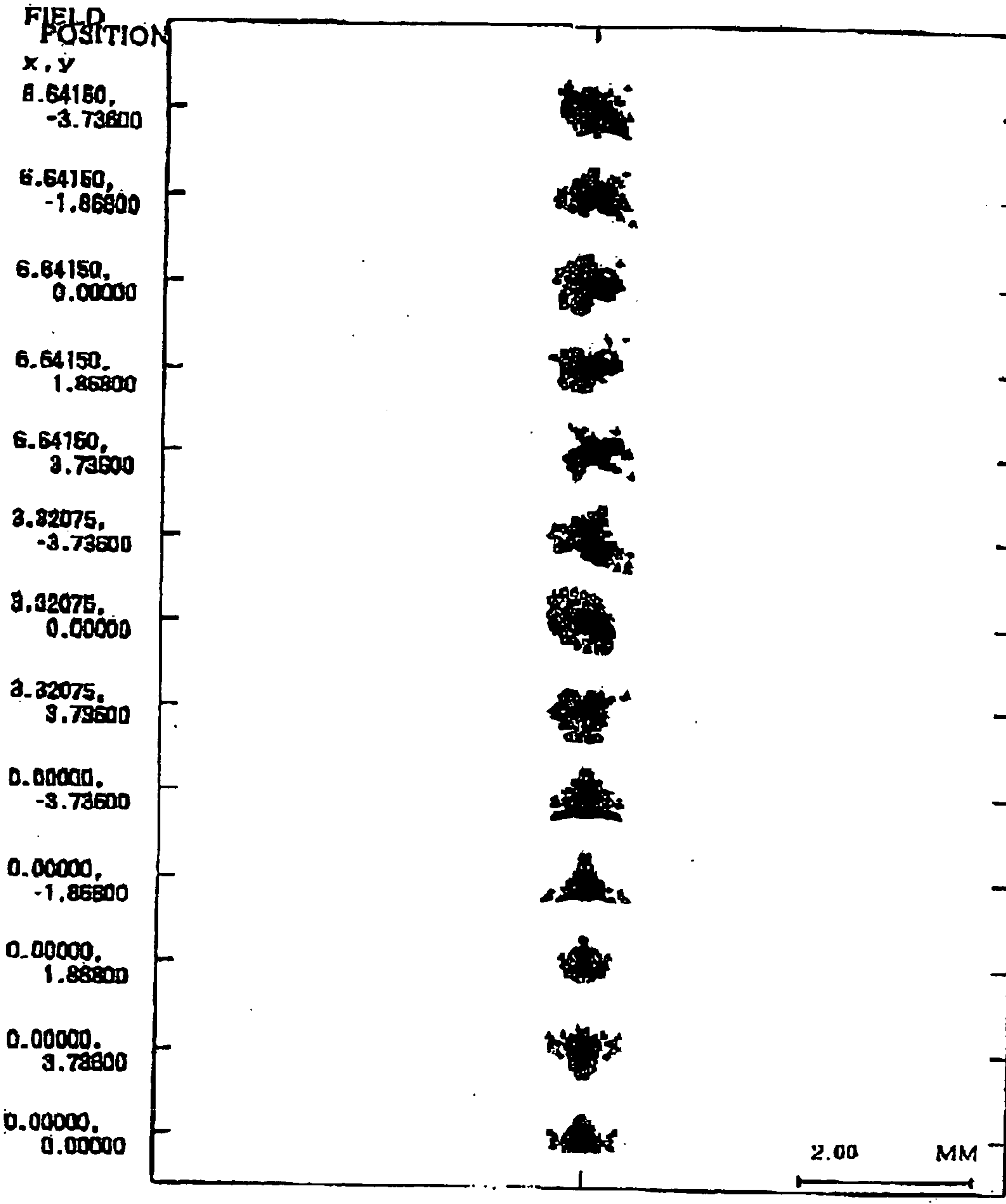
[Drawing 4]



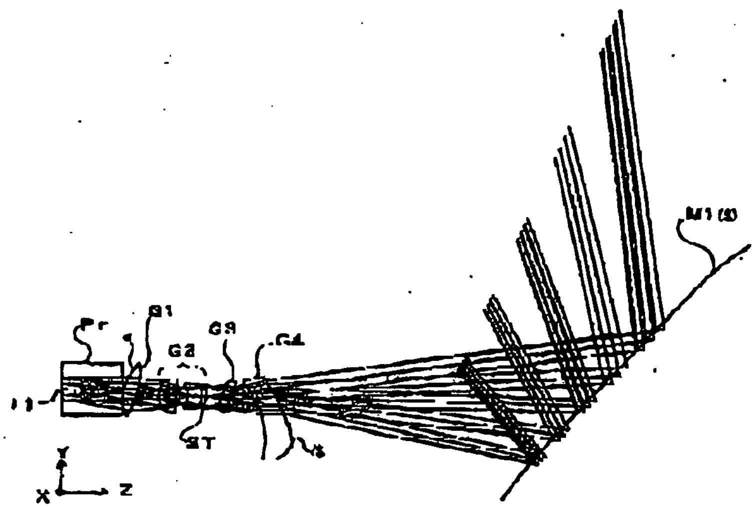
[Drawing 5]



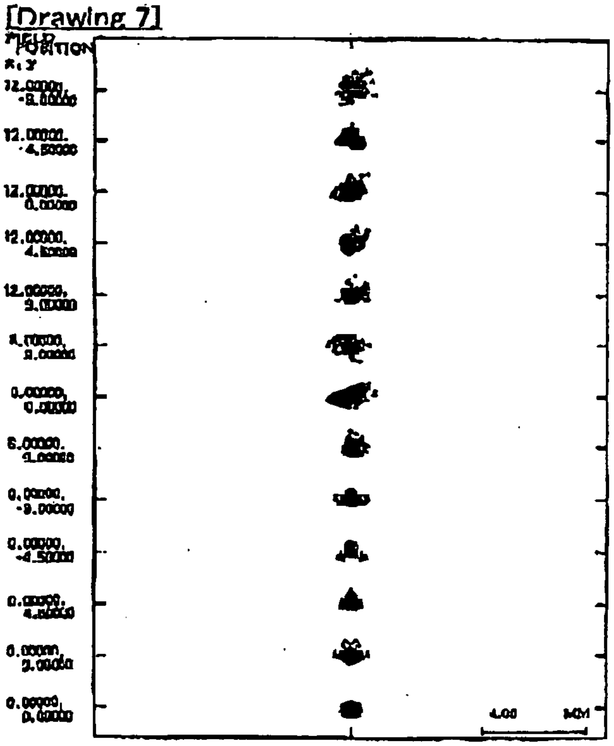
[Drawing 3]


FIELD
POSITION
x, y
6.64150,
-3.73600
6.64150,
-1.86800
6.64150,
0.00000
6.64150,
1.86800
6.64150,
3.73600
3.32075,
-3.73600
3.32075,
0.00000
3.32075,
3.73600
0.00000,
-3.73600
0.00000,
-1.86800
0.00000,
1.86800
0.00000,
3.73600
0.00000,
0.00000
2.00 MM

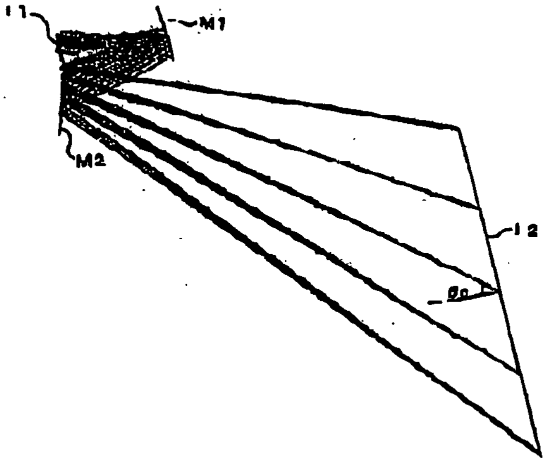
[Drawing 6]



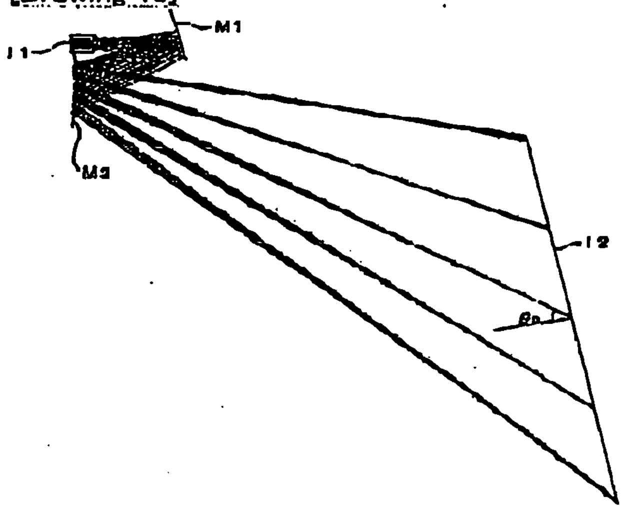
[Drawing 7]



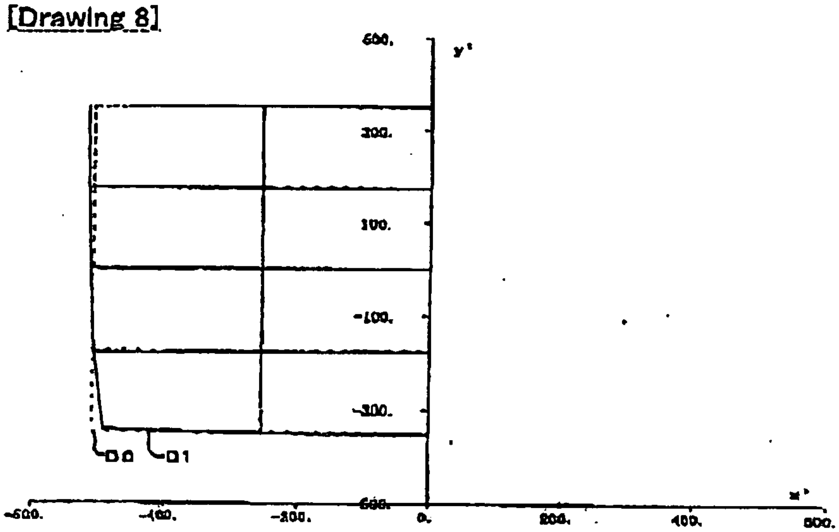
[Drawing 9]



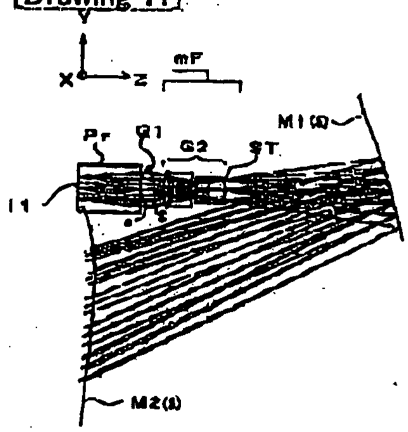
[Drawing 10]



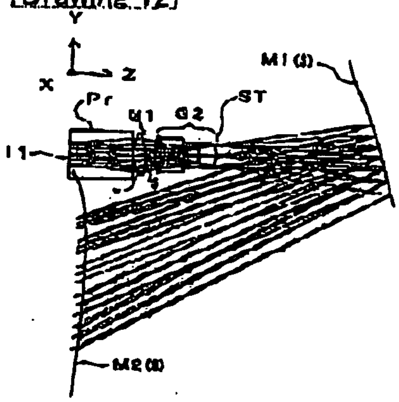
[Drawing 8]



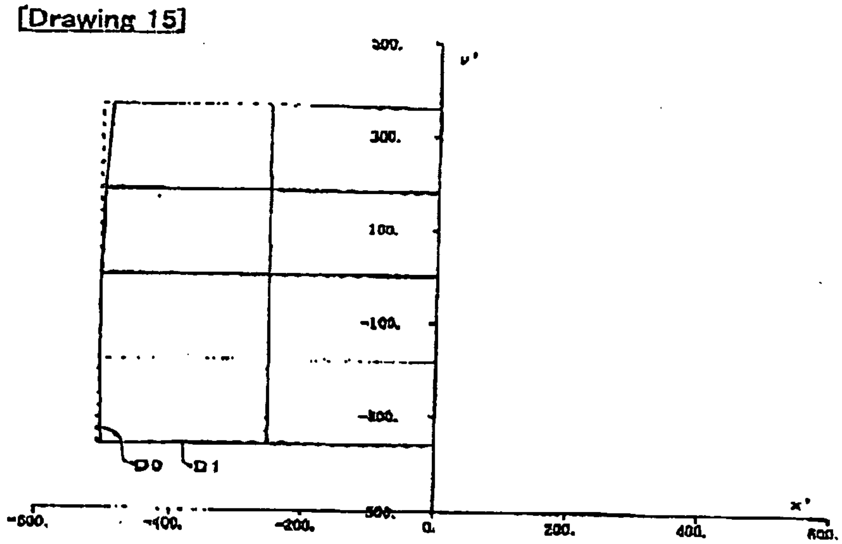
[Drawing 11]



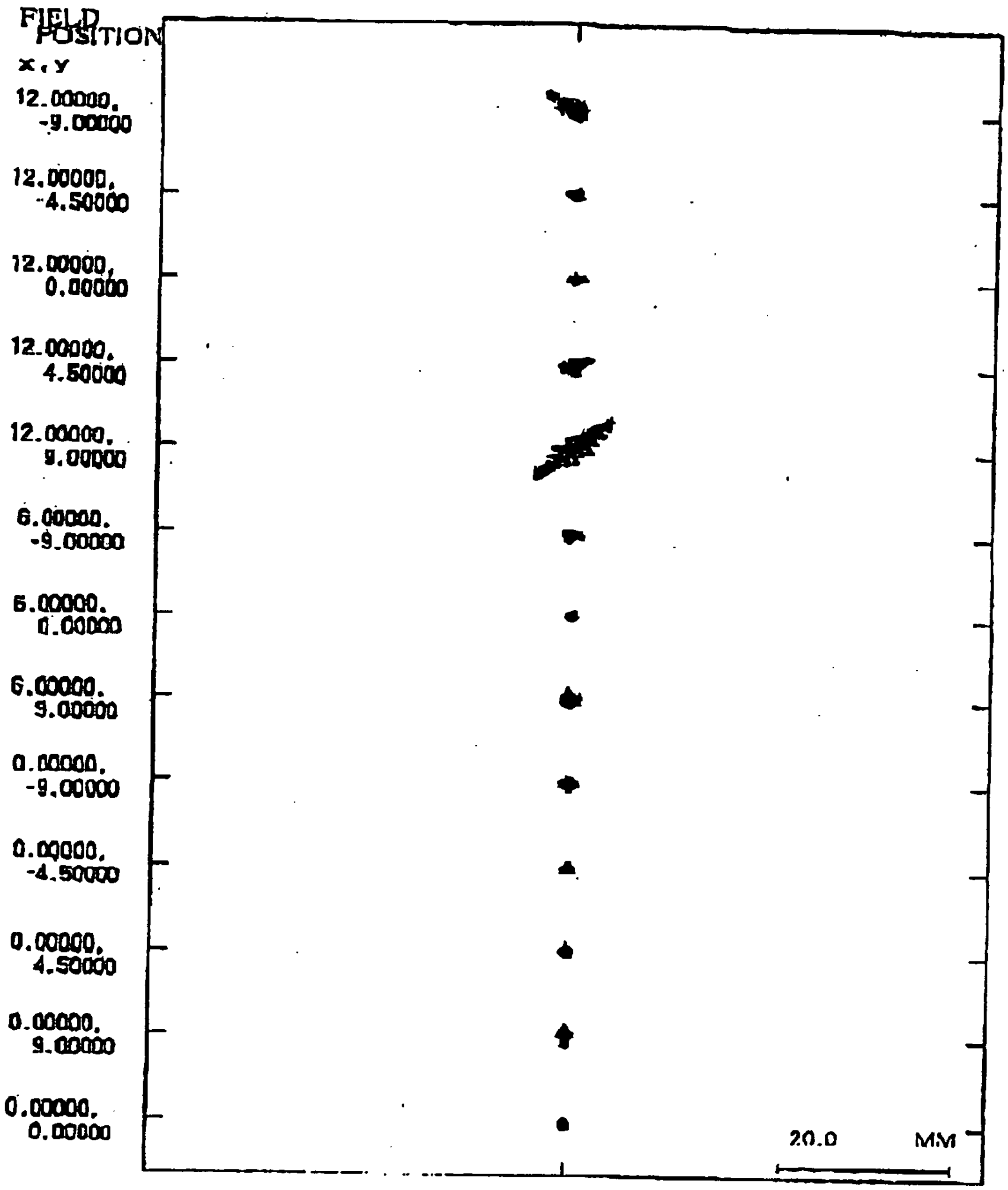
[Drawing 12]



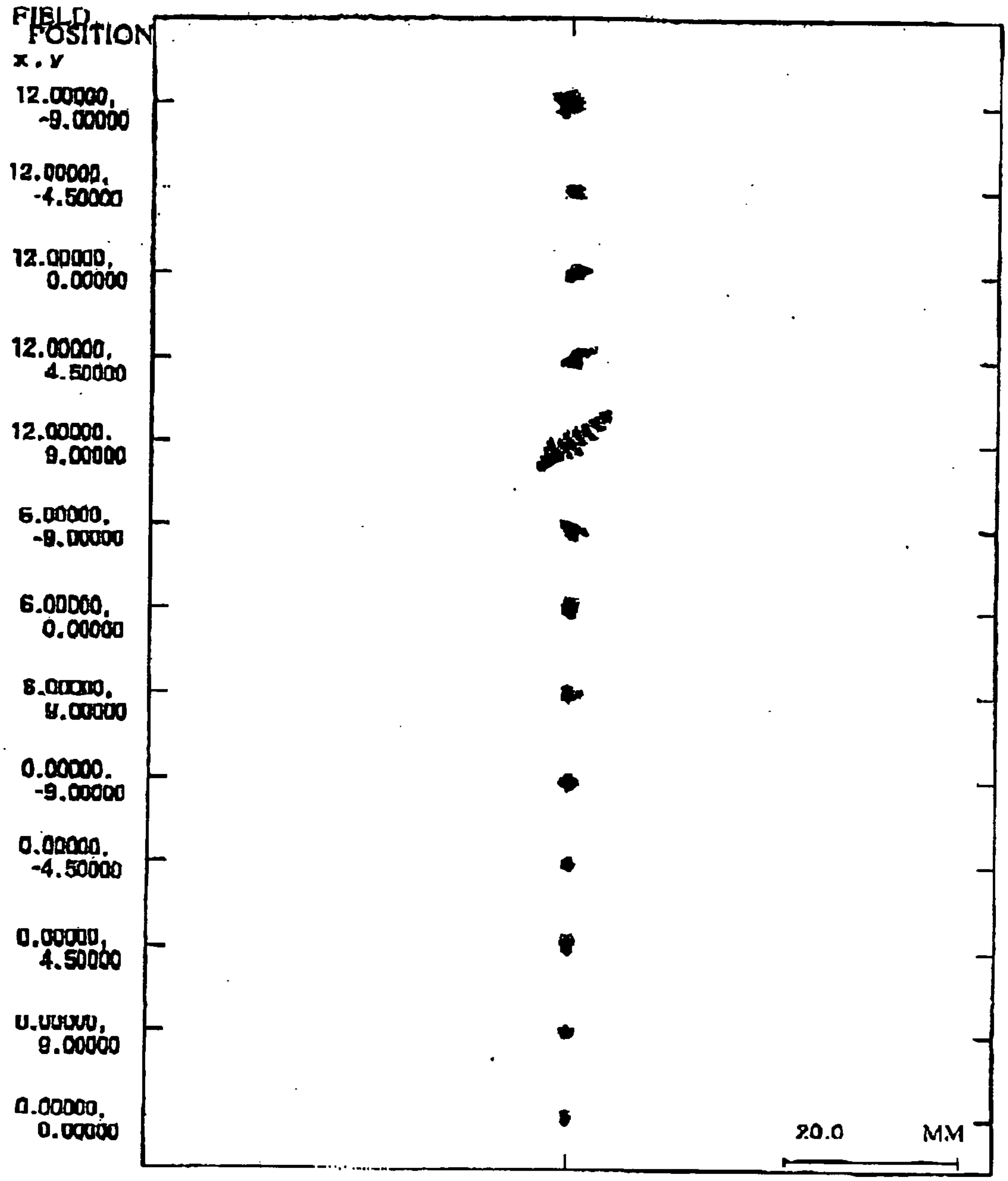
[Drawing 15]



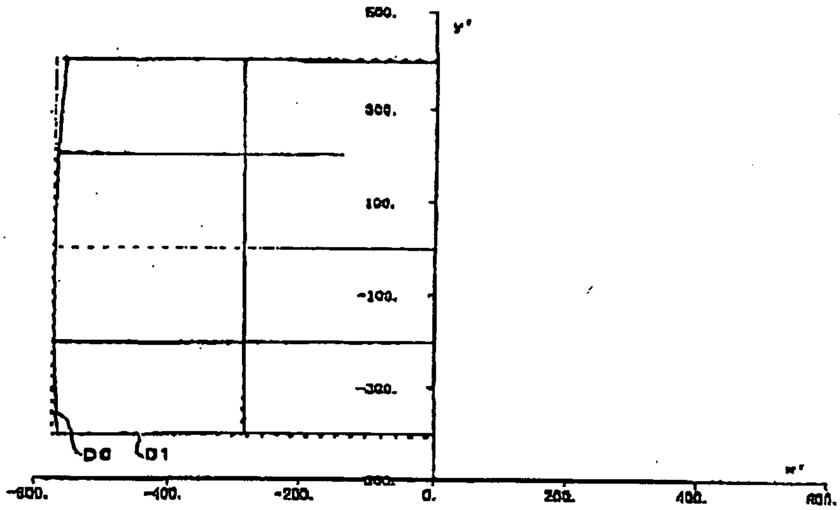
[Drawing 13]


FIELD POSITION
x, y
12.00000, -9.00000
12.00000, -4.50000
12.00000, 0.00000
12.00000, 4.50000
12.00000, 9.00000
6.00000, -9.00000
6.00000, 0.00000
6.00000, 9.00000
0.00000, -9.00000
0.00000, -4.50000
0.00000, 4.50000
0.00000, 9.00000
0.00000, 0.00000
20.0 MM

[Drawing 14]


FIELD POSITION
x, y
12.00000, -9.00000
12.00000, -4.50000
12.00000, 0.00000
12.00000, 4.50000
12.00000, 9.00000
6.00000, -9.00000
6.00000, 0.00000
6.00000, 9.00000
0.00000, -9.00000
0.00000, -4.50000
0.00000, 4.50000
0.00000, 9.00000
0.00000, 0.00000
20.0 MM

[Drawing 10]



[Translation done.]